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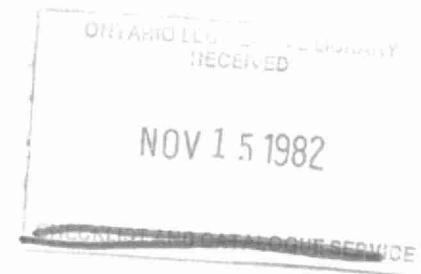
# PROVINCE OF ONTARIO

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**PRESENTATION TO  
THE MICHIGAN AIR POLLUTION CONTROL COMMISSION  
IN OPPOSITION TO THE DETROIT EDISON REQUEST TO  
DELAY BRINGING ITS MONROE POWER PLANT INTO  
COMPLIANCE WITH THE STATE OF MICHIGAN  
"1% OR EQUIVALENT SULPHUR IN FUEL" RULE.**

MONROE, MICHIGAN  
JUNE 30, 1982



Ministry  
of the  
Environment

Hon. Keith C. Norton, Q.C.,  
Minister

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Deputy Minister

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1. INTRODUCTION

TRADITIONALLY CANADA AND THE UNITED STATES HAVE FUNCTIONED AS GOOD NEIGHBOURS IN A WAY WHICH IS HISTORICALLY UNIQUE. FOR EXAMPLE, RECOGNIZING THAT THE EUTROPHICATION OF THE GREAT LAKES WAS MAINLY CAUSED FROM MANY SOURCES ON BOTH SIDES OF THE BORDER, THE GOVERNMENTS OF BOTH OUR COUNTRIES MADE THE COMMITMENT TO INVEST HUNDREDS OF MILLIONS OF DOLLARS TO CLEAN UP THE GREAT LAKES BY SIGNING THE 1972 AGREEMENT ON GREAT LAKES WATER QUALITY. THE SUCCESS OF THIS JOINT EFFORT CAN BE GAUGED BY THE MONITORING REPORTS WHICH SHOW DEFINITE IMPROVEMENT IN WATER QUALITY AND BY THE RENEWAL OF THE AGREEMENT IN 1978.

IN ADDITION, THE STATE OF MICHIGAN AND THE PROVINCE OF ONTARIO HAVE COOPERATED TO RESOLVE SPECIFIC ISSUES RELEVANT TO THE TWO JURISDICTIONS. AN EXAMPLE IS THE DETROIT/ONTARIO AIR POLLUTION STUDY (DOAPS) WHICH EXAMINED THE OZONE PROBLEM IN SOUTHEASTERN MICHIGAN AND SOUTHWESTERN ONTARIO DURING THE SUMMER OF 1981.

THAT RELATIONSHIP HAS ENABLED US TO WORK OUT MUTUAL PROBLEMS IN THE PAST. IT IS IN THE SPIRIT OF THAT CO-OPERATION THAT ONTARIO IS APPEARING HERE TODAY TO PUT FORWARD ITS POSITION, AND TO OFFER THE BENEFIT OF ITS EXPERIENCE AND KNOWLEDGE ABOUT THE ENVIRONMENTAL PROBLEM WE SHARE -- TRANSBOUNDARY AIR POLLUTION. THE TRANSBOUNDARY AIR POLLUTION PHENOMENON IS NOT GOVERNED BY

ANY RESPECT FOR INTERSTATE BOUNDARIES, NOR INDEED FOR INTERNATIONAL ONES. PUT SIMPLY, WHAT GOES UP FROM ONE BACKYARD CAN, AND OFTEN DOES, COME DOWN IN ANOTHER.

THERE IS A GROWING BODY OF EVIDENCE TO SUPPORT THE VIEW THAT AIRSHEDS CAN NO LONGER BE CONSIDERED AS ENTITIES WITH LOCALIZED BOUNDARIES AND SUBJECT TO MANAGEMENT BASED ON LOCAL RATIONALES. IN THE CASE OF ATMOSPHERIC POLLUTANTS, WE SHARE A COMMON AIRSHED. THUS, POLLUTION CONTROL TO PROTECT THE NORTH AMERICAN ENVIRONMENT MUST BE A SHARED RESPONSIBILITY AND COMMITMENT.

AS A RESULT, ONTARIO HAS AN INTEREST IN ANY HEARING THAT MAY INCREASE THE ATMOSPHERIC LOADING OF SO<sub>2</sub> TO THIS COMMON AIRSHED, OR THAT ATTEMPTS TO DELAY THE ENFORCEMENT OF AN EXISTING REGULATION WHICH, IF ENACTED, WOULD RESULT IN A DECREASE IN THE ATMOSPHERIC BURDEN OF SO<sub>2</sub>.

THE LATTER IS CURRENTLY THE ISSUE UNDER CONSIDERATION BY THE STATE OF MICHIGAN'S AIR POLLUTION CONTROL COMMISSION AT THIS HEARING. THE PURPOSE OF THIS HEARING IS TO CONSIDER THE REQUEST BY DETROIT EDISON TO DELAY BRINGING ITS MONROE POWER PLANT INTO COMPLIANCE WITH THE STATE OF MICHIGAN "1% OR EQUIVALENT SULPHUR IN FUEL" RULE.

AT THIS HEARING, THERE ARE SIGNIFICANT ISSUES THAT THE COMMISSION MUST CONSIDER IN DETERMINING THE ACCEPTABILITY OF THE EXTENSION REQUEST. ONE OF THESE ISSUES, AS NOTED

BY THE COMMISSION ITSELF, IS THE IMPLICATION OF THE REQUEST WITH RESPECT TO THE ACIDIC DEPOSITION PROBLEM WITHIN THE STATE OF MICHIGAN AND AFFECTED NEIGHBOURING JURISDICTIONS.

ONE NEEDS ONLY TO CONSIDER THE DAMAGE ALREADY DONE TO ONTARIO'S RECREATIONAL AREAS (SEE CHAPTER 5.) WHICH ARE SENSITIVE TO ATMOSPHERIC POLLUTANTS TO REALIZE THAT IF CONTINUED DEGRADATION IS TO BE PREVENTED AND FUTURE DAMAGE AVERTED, THEN A REDUCTION OF EMISSIONS IS NEEDED ON AN EASTERN NORTH AMERICAN BASIS AND ANY EXISTING REGULATION REQUIRING SUCH A DECREASE SHOULD NOT BE EXTENDED BUT STRICTLY ENFORCED.

THEREFORE, ONTARIO'S POSITION AT THIS HEARING AND ANY SIMILAR ONE IS TO SUPPORT THE ENFORCEMENT OF ANY REGULATION THAT WILL DECREASE THE ATMOSPHERIC BURDEN OF SO<sub>2</sub>. ONTARIO BELIEVES THAT THE ULTIMATE SOLUTION TO THE PROBLEM INVOLVES A REDUCTION IN EMISSIONS BY ALL SIGNIFICANT SOURCES IN ALL CONTRIBUTING JURISDICTIONS. TAKEN AGGREGATELY, THESE REDUCTIONS WILL LESSEN THE ATMOSPHERIC BURDEN OF ACID FORMING SUBSTANCES WHICH IS A PREREQUISITE FOR PROTECTING ONTARIO'S SENSITIVE AND VERY VALUABLE ENVIRONMENT.

IN SEARCH OF A SOLUTION TO THIS PROBLEM, CANADA AND THE UNITED STATES SIGNED A MEMORANDUM OF INTENT ON TRANSBOUNDARY AIR POLLUTION ON AUGUST 5, 1980, WHICH

COMMITTED BOTH NATIONS TO RESIST EMISSION INCREASES AND TO BRING ABOUT REDUCTIONS WHERE POSSIBLE PENDING CONCLUSION OF A COMPREHENSIVE INTERNATIONAL AGREEMENT.

IN THIS DOCUMENT, BOTH THE U.S. AND CANADA AGREED TO TAKE CERTAIN INTERIM ACTIONS. THESE INCLUDED THE DEVELOPMENT OF AIR POLLUTION CONTROL STRATEGIES AND THE VIGOROUS ENFORCEMENT OF EXISTING LAWS AND REGULATIONS "IN A WAY WHICH IS RESPONSIVE TO THE PROBLEMS OF TRANSBOUNDARY AIR POLLUTION".

ONTARIO IS HERE TODAY BECAUSE THE ACTION REQUESTED IN THIS INSTANCE IS CLEARLY IN VIOLATION OF BOTH THE SPIRIT AND INTENT OF THIS AUGUST 5, 1980, MEMORANDUM.

## 2. LEGAL AND POLICY CONSIDERATIONS

THE PRIMARY DUTY OF THE MICHIGAN AIR POLLUTION CONTROL COMMISSION IS TO PROTECT THE HEALTH AND WELFARE OF THE PEOPLE OF MICHIGAN. THIS IS ALSO THE MAIN OBJECTIVE OF MICHIGAN'S AIR POLLUTION CONTROL LAWS. HOWEVER, THE COMMISSION'S DUTIES ARE NOT CARRIED OUT IN A VACUUM. THE COMMISSION MUST INTERPRET AND APPLY THE LAWS IN THE CONTEXT OF A FRAMEWORK OF INTERNATIONAL LAW, PUBLIC POLICY, AND A TRADITION OF COOPERATION BETWEEN THE STATE OF MICHIGAN AND THE PROVINCE OF ONTARIO IN THE MANAGEMENT OF OUR COMMON AIR RESOURCES.

MICHIGAN'S AIR POLLUTION CONTROL LAWS MUST BE INTERPRETED IN LIGHT OF THE FACT THAT MICHIGAN AND ONTARIO SHARE A COMMON AIRSHED, COMMON BODIES OF WATER, AND A COMMON PROBLEM OF ACIDIC DEPOSITION. THE AIR WHICH IS OVER MICHIGAN TODAY MAY BE OVER ONTARIO TOMORROW, AND VICE VERSA. IT IS NOT ONLY IN THE INTERESTS OF ONTARIO TO CONTROL EMISSIONS THAT MAY CONTRIBUTE TO ACID RAIN, BUT ALSO IN THE INTERESTS OF THE CITIZENS OF MICHIGAN, IN LIGHT OF RECENT EVIDENCE OF A POTENTIAL FOR ACIDIC DEPOSITION TO DESTROY FISH AND OTHER AQUATIC ORGANISMS IN THE UPPER MICHIGAN PENINSULA. (SEE CHAPTER FIVE.) THE EVIDENCE THAT EMISSIONS FROM THE MONROE PLANT DEPOSIT ACID FORMING SUBSTANCES IN ONTARIO IS ALSO EVIDENCE THAT THE SAME EMISSIONS ARE DEPOSITING ACID FORMING SUBSTANCES IN THE UPPER MICHIGAN PENINSULA, AS IN MANY INSTANCES THE SAME BODY OF AIR PASSES OVER THE UPPER MICHIGAN PENINSULA

BEFORE ARRIVING IN ONTARIO. UNDER THESE CIRCUMSTANCES, A DECISION TO HELP ONTARIO IS ALSO A DECISION TO HELP MICHIGAN.

APART FROM ANY SELF-INTEREST MICHIGAN MAY HAVE IN LIMITING EMISSIONS FROM THE MONROE PLANT, WE WOULD SUGGEST THAT ALTHOUGH THE PRIMARY MANDATE OF THE COMMISSION MAY BE TO PROTECT MICHIGAN'S AIR QUALITY, THIS DOES NOT RESTRICT THE COMMISSION TO CONSIDERING IMPACTS WITHIN MICHIGAN EXCLUSIVELY. MICHIGAN'S DOMESTIC LAWS CAN BE INTERPRETED IN THE CONTEXT OF WELL-ESTABLISHED PRINCIPLES OF INTERNATIONAL LAW. THE TRAIL SMELTER CASE ESTABLISHES THE PRINCIPLE THAT A STATE OWES AT ALL TIMES A DUTY TO PROTECT OTHER STATES AGAINST INJURIOUS ACTS BY INDIVIDUALS FROM WITHIN ITS JURISDICTION. INTERNATIONAL DECISIONS IN VARIOUS MATTERS, ACCORDING TO THE TRAIL SMELTER CASE, ARE BASED ON THE SAME GENERAL PRINCIPLE.

THE PRINCIPLE WAS STATED IN THE FOLLOWING LANGUAGE:

"...UNDER THE PRINCIPLES OF INTERNATIONAL LAW, NO STATE HAS THE RIGHT TO USE OR PERMIT THE USE OF ITS TERRITORY IN SUCH MANNER AS TO CAUSE INJURY BY FUMES IN OR TO THE TERRITORY OF ANOTHER OR THE PROPERTIES OR PERSONS THEREIN, WHEN THE CASE IS OF SERIOUS CONSEQUENCE AND THE INJURY IS ESTABLISHED BY CLEAR AND CONVINCING EVIDENCE".

IN ADDITION, THE COMMISSION'S DELIBERATIONS TAKE PLACE IN THE CONTEXT OF AN AGREEMENT BETWEEN THE GOVERNMENT OF CANADA AND THE GOVERNMENT OF THE UNITED STATES TO PROMOTE VIGOROUS ENFORCEMENT OF EXISTING LAWS AND REGULATIONS IN A WAY WHICH IS RESPONSIVE TO THE PROBLEMS OF TRANSBOUNDARY AIR POLLUTION.

FINALLY, A FURTHER INDICATION THAT THE STATE LEGISLATURE INTENDS THE COMMISSION TO CARRY OUT ITS MANDATE IN A SPIRIT OF COOPERATION WITH THE PROVINCE OF ONTARIO IS THE MEMORANDUM OF UNDERSTANDING SIGNED IN 1974 BY THE GOVERNOR OF THE STATE OF MICHIGAN AND THE PREMIER OF THE PROVINCE OF ONTARIO PROVIDING FOR COOPERATION IN IMPLEMENTING AIR POLLUTION CONTROL PROGRAMS TO CONTROL AIR POLLUTION IN THE TRANSBOUNDARY AREA BETWEEN SOUTHWESTERN ONTARIO AND SOUTHEASTERN MICHIGAN. THIS "MEMORANDUM OF UNDERSTANDING ON TRANSBOUNDARY AIR POLLUTION CONTROL IN SOUTHWESTERN ONTARIO - SOUTHEASTERN MICHIGAN AREA" RECITES THAT THE TWO GOVERNMENTS ARE INTENT UPON ACCELERATING CONTROL PROGRAMS TO IMPROVE AIR QUALITY IMPAIRED BY EXISTING SOURCES OF AIR POLLUTION IN THE DETROIT AND ST. CLAIR RIVER AREA AND DESIRE TO ASSURE COOPERATION TO PREVENT THE CREATION OF NEW SOURCES OF TRANSBOUNDARY AIR POLLUTION. IT ESTABLISHES A NUMBER OF PROGRAMS INCLUDING CONTROLS OVER POINT SOURCES OF POLLUTION, MONITORING AND SURVEILLANCE OF AIR QUALITY, MAINTENANCE OF JOINT PROCEDURES FOR ACTIONS TO CONTROL AND PREVENT AIR POLLUTION EPISODES WHICH MAY BE OBSERVED

OR PREDICTED, AND REGULAR EXCHANGE OF AIR QUALITY DATA AND REPORTS OF PROGRESS OF COMPLIANCE WITH ABATEMENT SCHEDULES.

ONTARIO IS SUBJECT TO ACIDIC DEPOSITION WHICH IS ALREADY RESULTING IN HARMFUL EFFECTS ON ONTARIO'S LAKES AND AQUATIC LIFE. (SEE CHAPTER FIVE). THERE IS EVIDENCE THAT EMISSIONS FROM POWER PLANTS IN THE EASTERN AND MID-WESTERN UNITED STATES SIGNIFICANTLY CONTRIBUTE TO ACIDIC DEPOSITION. SINCE COAL-FIRED POWER PLANTS ARE A SIGNIFICANT SOURCE OF ACIDIC DEPOSITION, THE ONTARIO MINISTRY OF THE ENVIRONMENT HAS RANKED THE FIFTY TOP COAL-FIRED POWER PLANTS IN EASTERN NORTH AMERICA ACCORDING TO THEIR TOTAL SO<sub>2</sub> EMISSIONS. THE DETROIT EDISON MONROE PLANT IS FIFTH ON THAT LIST WITH AN ESTIMATED 264.9 THOUSAND METRIC TONS OF SO<sub>2</sub> EMISSIONS IN THE YEAR 1979, THE YEAR FOR WHICH THE DATA WAS COLLECTED.

THESE FIFTY PLANTS CONTRIBUTE TO EMISSIONS OF SO<sub>2</sub> WHICH ARE PRECURSORS TO ACIDIC RAIN IN ONTARIO. THIS GIVES THE PROVINCE OF ONTARIO A SIGNIFICANT INTEREST IN THE OUTCOME OF ANY PROCEEDINGS THAT MAY AFFECT THE QUANTITY OF ALLOWABLE SULPHUR DIOXIDE EMISSIONS FROM ANY OF THESE POWER PLANTS. ONTARIO BELIEVES THAT RIGHTS CONFERRED BY ACCORDS, BY PRINCIPLES OF INTERNATIONAL LAW, AND BY SECTION 115 OF THE U.S. CLEAN AIR ACT GIVE THE PROVINCE NOT ONLY A SIGNIFICANT INTEREST IN THE OUTCOME OF SUCH PROCEEDINGS, BUT ALSO A RIGHT TO ADVANCE NOTIFICATION AND

CONSULTATION ON PROPOSED ACTIONS INVOLVING A SIGNIFICANT RISK OF CAUSING OR INCREASING TRANSBOUNDARY POLLUTION, AND A RIGHT TO BE FREE FROM HARM TO ITS ENVIRONMENT CAUSED BY ACTIVITIES IN THE TERRITORY OF ANOTHER COUNTRY.

THE FOLLOWING WILL HIGHLIGHT CERTAIN ASPECTS OF THE LEGAL AND POLICY CONSIDERATIONS REFERRED TO ABOVE.

FIRST, UNDER THE PRINCIPLE SET OUT IN THE TRAIL SMELTER CASE, THAT NO COUNTRY HAS THE RIGHT TO POLLUTE A NEIGHBOURING COUNTRY, WE WOULD SUGGEST THAT IT DOES NOT MATTER THAT THE MONROE PLANT IS ONLY ONE OF MANY POWER PLANTS WHOSE EMISSIONS SIGNIFICANTLY CONTRIBUTE TO THE ATMOSPHERIC BURDEN WHICH IS DETRIMENTALLY AFFECTING ONTARIO'S ENVIRONMENT. THE FACT THAT NO SINGLE SOURCE OF EMISSIONS MAY BY ITSELF BE A MAJOR CONTRIBUTOR TO ACIDIC RAIN AND DEPOSITION DOES NOT EXCUSE ANY FAILURE TO DEAL WITH EACH SOURCE INDIVIDUALLY. WHEN CONFRONTED WITH HARM CAUSED BY POLLUTION FROM MANY SOURCES, WHERE THERE IS DIFFICULTY IN SEGREGATING AND MEASURING THE IMPACTS OF INDIVIDUAL SOURCES, THE COURTS HAVE STILL BEEN ABLE TO DESIGN EFFECTIVE REMEDIES BY APPLYING TRADITIONAL TORT PRINCIPLES. FOR EXAMPLE, THE SUPREME COURT OF THE UNITED STATES HAS RECOGNIZED TRADITIONAL PRINCIPLES OF TORT LAW IN THE CONTEXT OF INTER-STATE AIR OR WATER POLLUTION. THE COURT HAS FASHIONED A FEDERAL COMMON LAW OF NUISANCE.

THUS, THE SUPREME COURT HAS IMPLICITLY ADOPTED THE PRINCIPLE OF TORT LAW THAT WHERE THERE ARE MANY SOURCES OF CONTAMINATION, EACH MAY BE LIABLE FOR ITS PORTION OF THE DAMAGE CAUSED CUMULATIVELY BY ALL OF THEM. IT IS NO DEFENCE THAT OTHERS ARE ALSO CONTRIBUTING TO THE DAMAGE. (ILLINOIS V. MILWAUKEE, 406 U.S. 91 (1972)). THE FACT THAT EACH CONTRIBUTOR MAY BE JOINTLY AND SEVERALLY LIABLE FOR DAMAGE HAS ALSO BEEN RECOGNIZED BY OTHER U.S. COURTS (MICHIE V. GREAT LAKES STEEL, 495 F. 2d 13, 4 ERL 20324 (6th CIRCUIT 1974), CERT. DENIED 419 IN THE U.S. 997, 95S. CP. 310 (1974)).

THE COURTS, OF COURSE, APPLY THESE PRINCIPLES WITHOUT THE NEED FOR EXPLICIT STATUTORY LANGUAGE, AND WE WOULD SUGGEST THAT THE STATE OF MICHIGAN SHOULD APPLY THE SAME KIND OF REASONING PROCESS IN REACHING ITS DECISION IN THIS CASE.

SECONDLY, ONTARIO WISHES TO DRAW TO THE ATTENTION OF THE COMMISSION THE MEMORANDUM OF INTENT CONCERNING TRANSBoundary AIR POLLUTION ENTERED INTO ON AUGUST 5, 1980, BY THE GOVERNMENT OF CANADA AND THE GOVERNMENT OF THE UNITED STATES. IN THIS DOCUMENT, THE PARTIES DECLARED THEIR INTENTION "TO DEVELOP A BILATERAL AGREEMENT WHICH WILL REFLECT AND FURTHER THE DEVELOPMENT OF EFFECTIVE DOMESTIC CONTROL PROGRAMS AND OTHER MEASURES TO COMBAT TRANSBoundary AIR POLLUTION".

BOTH PARTIES AGREED TO TAKE CERTAIN INTERIM ACTIONS PENDING CONCLUSION OF SUCH AN AGREEMENT. THESE INTERIM ACTIONS INCLUDED THE FOLLOWING UNDERTAKINGS WITH RESPECT TO CONTROL MEASURES:

"TO COMBAT TRANS-BOUNDARY AIR POLLUTION BOTH GOVERNMENTS SHALL:

- (A) DEVELOP DOMESTIC AIR POLLUTION CONTROL POLICIES AND STRATEGIES AS NECESSARY AND APPROPRIATE, SEEK LEGISLATIVE OR OTHER SUPPORT TO GIVE EFFECT TO THEM;
- (B) PROMOTE VIGOROUS ENFORCEMENT OF EXISTING LAWS AND REGULATIONS AS THEY REQUIRE LIMITATIONS OF EMISSIONS FROM NEW, SUBSTANTIALLY MODIFIED AND EXISTING FACILITIES IN A WAY WHICH IS RESPONSIVE TO THE PROBLEMS OF TRANS-BOUNDARY AIR POLLUTION; AND
- (C) SHARE INFORMATION AND CONSULT ON ACTIONS BEING TAKEN PURSUANT TO (A) AND (B)."

WITH REGARD TO THE GOAL SHARED BY BOTH GOVERNMENTS OF PROMOTING THE VIGOROUS ENFORCEMENT OF EXISTING LAWS AND REGULATIONS, ONTARIO WOULD LIKE TO POINT OUT THAT THIS GOAL IS CONSISTENT WITH THE RULES OF THE STATE OF MICHIGAN GOVERNING HOW THE COMMISSION WILL DECIDE ON

REQUESTS FOR EXTENSIONS OF NON-COMPLIANCE WITH STATE STANDARDS, IN PARTICULAR, THE REQUIREMENT THAT EXTENSIONS WILL ONLY BE GIVEN WHEN PROGRESS TOWARDS ULTIMATE COMPLIANCE IS BEING DEMONSTRATED. SINCE THIS IS THE THIRD COMPLIANCE EXTENSION REQUESTED BY THE COMPANY, IT IS QUESTIONABLE WHETHER DETROIT EDISON INTENDS EVER TO COMPLY WITH THE ONE PERCENT SULPHUR RULE.

ONTARIO URGES THE COMMISSION TO TAKE ACCOUNT OF THE ABOVE UNDERTAKINGS AND TO MAKE ITS DECISION WITH RESPECT TO THIS REQUEST FOR AN EXTENSION OF NON-COMPLIANCE IN A MANNER CONSISTENT WITH SUCH UNDERTAKINGS. ONTARIO IS NOT ASKING THE STATE TO MAKE NEW LAWS TO DEAL WITH THE PROBLEM OF TRANSBOUNDARY POLLUTION, BUT ONLY TO ENFORCE ITS EXISTING LAWS AND REGULATIONS VIGOROUSLY. TO FAIL TO REQUIRE SUBSTANTIAL PROGRESS WOULD BE CONTRARY NOT ONLY TO MICHIGAN'S OWN CRITERIA FOR GRANTING EXTENSIONS, BUT ALSO TO THE SPIRIT OF THE MEMORANDUM OF INTENT. WE URGE THAT PENDING THE FINALIZATION OF AN INTERNATIONAL AGREEMENT ON TRANSBOUNDARY AIR POLLUTION, THE STATE OF MICHIGAN SHOULD USE ITS BEST EFFORTS TO MAKE THE MONROE PLANT COMPLY WITH PRESENT LIMITS, RATHER THAN ALLOW AN EXTENSION WHICH MAY IN EFFECT AMOUNT TO RAISING THOSE LIMITS.

3. ONTARIO'S LRTAP PROGRAM

HISTORICALLY, ENVIRONMENT ONTARIO AND OTHER NORTH AMERICAN JURISDICTIONS HAVE BEEN DEALING WITH CONTAMINANTS AS POLLUTANTS IN THEIR OWN RIGHT, CONCERNED WITH THEIR POTENTIAL "LOCALIZED" AND "COMMUNITY" EFFECTS.

TO AID IN THIS ACTIVITY, THE ONTARIO ENVIRONMENT MINISTRY ESTABLISHED A PROVINCE-WIDE INVENTORY OF AIR CONTAMINANTS IN 1972, WHICH INCLUDES SULPHUR DIOXIDE. CONCENTRATIONS OF 30 KNOWN AIR-BORNE CONTAMINANTS ARE MEASURED BY A MONITORING NETWORK DISTRIBUTED THROUGHOUT ONTARIO WHICH CONSISTS OF APPROXIMATELY 1,400 AIR QUALITY AND DEPOSITION MONITORING INSTRUMENTS, SOME OF WHICH ARE OPERATED ON A SPECIAL STUDY BASIS. THIS MONITORING NETWORK WAS ESTABLISHED TO OBTAIN COMPREHENSIVE KNOWLEDGE OF THE AIR QUALITY AND POLLUTANT DEPOSITION IN ONTARIO. THE DATA HAS BEEN RELATED TO EMITTING SOURCES AND, IN ASSOCIATION WITH AIR QUALITY SIMULATION MODELS, HAS BEEN USED TO DEVELOP CONTROL STRATEGIES FOR THESE SOURCES WHEN AIR QUALITY CRITERIA SET BY THE PROVINCE WERE EXCEEDED.

HOWEVER, STUDIES OF GENERATION AND TRANSPORT OF TOTAL SUSPENDED PARTICULATES AND THE PHOTOCHEMICAL PRODUCT, OZONE, HAVE INDICATED THAT A LARGE CONTRIBUTION WAS ATTRIBUTABLE TO OUT-OF-PROVINCE SOURCES. MORE RECENTLY, ACIDIC PRECIPITATION STUDIES HAVE DEMONSTRATED

THAT THE PRECURSORS, SO<sub>2</sub>, SULPHATES, AND NITRATES, ARE FROM SOURCES WHICH, IN MANY CASES, ARE DISTANT FROM THE SENSITIVE RECEPTOR LAKES. THE SEVERITY OF THIS PROBLEM OF LONG RANGE TRANSPORT INTO ONTARIO BECAME APPARENT TO ONTARIO SCIENTISTS WHEN THEY BEGAN TO ANALYSE THE RESULTS FROM SEVERAL SPECIAL STUDIES, IN PARTICULAR, THE SUDBURY ENVIRONMENTAL AND LAKESHORE CAPACITY STUDIES. BOTH OF THESE GEOGRAPHICALLY INTENSIVE PROGRAMS MEASURED ATMOSPHERIC POLLUTANTS AND QUANTIFIED THE PROPORTION WHICH, AS A CONSEQUENCE OF VARIOUS PHYSICAL AND CHEMICAL MEANS, ULTIMATELY END UP IN SENSITIVE TERRESTRIAL AND AQUATIC ECOSYSTEMS.

IN PARTICULAR, THESE STUDIES INDICATED THAT, WHEN USING CONTEMPORARY MONITORING AND ANALYTICAL TECHNIQUES, THE SECONDARY OR EVOLUTIONARY POLLUTANTS ASSOCIATED WITH PRIMARY EMISSIONS OF PARTICULATES AND SO<sub>2</sub> WERE BEING DEPOSITED IN LARGE MEASURE BY THE RAIN FALLING OVER EXTENSIVE PORTIONS OF THE PROVINCE. FURTHERMORE, THIS POLLUTED RAIN WAS AND IS SERIOUSLY AFFECTING ONTARIO'S VERY SENSITIVE ENVIRONMENT.

IN RESPONSE TO THE SERIOUSNESS OF THIS SITUATION AND RECOGNIZING ITS SIMILARITY WITH THE SCANDINAVIAN PROBLEM, THE ONTARIO GOVERNMENT INITIATED A MAJOR LONG RANGE TRANSPORT OF ATMOSPHERIC POLLUTANTS OR "ACIDIC PRECIPITATION" PROGRAM IN 1979.

CURRENTLY THIS PROGRAM HAS A BUDGET IN EXCESS OF TEN MILLION DOLLARS WHICH EQUATES TO AN EXPENDITURE OF OVER \$1.00 PER CAPITA PER YEAR.

THE MAJOR ELEMENTS OF THIS EFFORT INCLUDE THE FOLLOWING UNDERTAKEN IN PARALLEL:

1. ATMOSPHERIC PROCESSES STUDIES WHICH INCLUDE EMISSIONS INVENTORIES, MODELLING AND METEOROLOGY STUDIES, DEPOSITION MONITORING NETWORKS AND THE DEVELOPMENT OF AN OXIDANTS STRATEGY.
2. AQUATIC EFFECTS STUDIES WHICH INCLUDE CALIBRATED WATERSHEDS, FISHERIES STUDIES, EXTENSIVE LAKE SAMPLING, REMEDIAL METHODOLOGIES DEVELOPMENT STUDIES, AND INTEGRATED WATER QUALITY/FISHERIES STUDIES IN SEVERAL LAKES.
3. TERRESTRIAL EFFECTS STUDIES WHICH INCLUDE BASELINE VEGETATION AND SOIL SURVEYS, SOIL SENSITIVITY MAPPING, EXPERIMENTAL STUDIES (LABORATORY SIMULATION) AND STUDIES AT THREE INTENSIVE BIOGEOCHEMICAL SITES.
4. SOCIO-ECONOMIC INVESTIGATIONS IN THE FOLLOWING AREAS: DAMAGES AND BENEFITS, COST OF ABATEMENT AND MITIGATION, AND CONTROL STRATEGY DEVELOPMENT AND EVALUATION.

5. LEGAL INITIATIVES BOTH WITHIN THE PROVINCE'S  
JURISDICTION AND IN INTERNATIONAL FORA.

6. PUBLIC RELATIONS INITIATIVES BOTH WITHIN THE  
PROVINCE OF ONTARIO AND ON AN INTERNATIONAL LEVEL.

#### 4. THE LRTAP PHENOMENON

THE RECOGNITION THAT AIR POLLUTANTS CAN BE TRANSPORTED FAR BEYOND THEIR LOCAL ORIGINS IS NOT NEW. ONE OF THE EARLIEST REFERENCES TO THE EXISTENCE OF A LONG RANGE TRANSPORT PHENOMENON OCCURRED IN THE MID 19TH CENTURY.<sup>4</sup> THE FREQUENCY OF SUCH REFERENCES HAS INCREASED OVER THE PAST ONE HUNDRED YEARS.

HOWEVER, ACTUAL SCIENTIFIC INVESTIGATIONS OF THE VARIOUS ASPECTS OF THIS PROBLEM HAVE ONLY BEEN INCREASING OVER THE PAST 15 TO 20 YEARS. THE FUNDAMENTAL FINDINGS OF THIS RESEARCH HAVE ESTABLISHED THAT A NUMBER OF PRIMARY AND SECONDARY AIR POLLUTANTS, INCLUDING PARTICULATES, CARBON MONOXIDE, OZONE, SULPHATES, NITRATES AND VARIOUS ORGANIC COMPOUNDS CAN UNDERGO LONG RANGE TRANSPORT. IN FACT LONG RANGE TRANSPORT HAS NOT ONLY BEEN DOCUMENTED ON A REGIONAL SCALE (100 - 300 KM), BUT ALSO ON THE CONTINENTAL (500 - 1000 KM) AND EVEN THE HEMISPHERIC OR GLOBAL (1000 - 5000 KM) SCALES. HOWEVER, DUE TO THE AVAILABILITY OF CONSIDERABLY MORE DATA ON THE REGIONAL AND CONTINENTAL SCALES, OBSERVATIONS CAN BE MADE TO LINK SUCH TRANSPORT TO VISIBILITY DEGRADATION, AQUATIC AND TERRESTRIAL IMPACTS, MATERIALS DAMAGE, ETC.

IN THE LAST 10 YEARS, INTENSIVE FIELD INVESTIGATIONS HAVE BEEN INITIATED IN BOTH EUROPE AND NORTH AMERICA. THESE

STUDIES HAVE CENTERED ON INCREASING THE UNDERSTANDING OF THE CYCLES AND BUDGETS OF SULPHUR POLLUTION. THE VARIOUS COMPONENTS OF THESE STUDIES HAVE INCLUDED CHARACTERIZATION AND DEVELOPMENT OF EMISSION INVENTORIES; IMPROVEMENT OF THE UNDERSTANDING OF THE DYNAMIC MECHANISMS AND PROCESSES LEADING TO LONG RANGE TRANSPORT; POLLUTANT TRANSFORMATION AND POLLUTANT REMOVAL (WET/DRY DEPOSITION); THE MEASUREMENT OF HORIZONTAL AND VERTICAL SULPHUR DISTRIBUTION (MEASUREMENT AND ANALYSIS OF PARTICULATES AND PRECIPITATION CHEMISTRY); AND THE DEVELOPMENT AND REFINEMENT OF MESOSCALE MODELS.

AS A RESULT OF THESE AND OTHER STUDIES, A NUMBER OF IMPORTANT FINDINGS ON THE NATURE OF LONG RANGE TRANSPORT OF NITROGEN AND SULPHUR OXIDES (INCLUDING THEIR TRANSFORMATION PRODUCTS) IN EASTERN NORTH AMERICA CAN BE STATED. THESE FINDINGS INCLUDE:

- \* MARITIME TROPICAL AIR MASSES FROM THE GULF OF MEXICO THAT OCCUR IN THE LATE SUMMER HAVE THE GREATEST POTENTIAL FOR FORMATION AND TRANSPORT OF HIGH CONCENTRATIONS OF SULPHATE INTO THE NORTHEASTERN UNITED STATES AND INTO EASTERN CANADA. CONVECTIVE SHOWERS ARE ALSO TYPICAL OF THESE AIR MASSES WHICH CAN LEAD TO ACIDIC PRECIPITATION.
  
- \* THE MECHANISMS OF THE CHEMICAL REACTIONS ASSOCIATED WITH ACIDIC DEPOSITION ARE QUITE COMPLEX AND DEPEND

ON A HOST OF VARIABLES. THEY RANGE FROM THE PHYSICAL PROPERTIES OF THE POLLUTANTS TO WEATHER CONDITIONS AND THE PRESENCE OF CATALYTIC OR INTERACTING AGENTS. EVEN THOUGH THESE CHEMICAL PROCESSES ARE NOT VERY WELL UNDERSTOOD, IT DOES APPEAR THAT LONG RANGE TRANSPORT OF SULPHUR COMPOUNDS CAN COVER 1000 TO 2000 KM OVER THREE TO FIVE DAYS.

- \* ACIDIC PRECIPITATION HAS RECEIVED INTENSIVE STUDY IN SOUTHERN SCANDINAVIA. THIS RESEARCH HAS SHOWN THAT ACIDIC RAIN IN NORWAY AND SWEDEN PRIMARILY RESULTS FROM LARGE SCALE TRANSPORT OF NITROGEN AND SULPHUR OXIDE EMISSIONS IN GREAT BRITAIN AND THE INDUSTRIAL REGIONS OF CONTINENTAL WESTERN EUROPE (E.G. WEST GERMANY, BELGIUM, HOLLAND, FRANCE).
- \* AIR POLLUTION PROBLEMS ASSOCIATED WITH SULPHUR COMPOUNDS ARE OF A LARGE-SCALE REGIONAL NATURE IN EASTERN NORTH AMERICA, AFFECTING BOTH CANADA AND THE UNITED STATES. POLLUTION PROBLEMS ON THIS SCALE RESULT FROM THE ATMOSPHERIC TRANSPORT OF EMISSIONS OVER DISTANCES OF HUNDREDS TO THOUSANDS OF KILOMETRES DOWNWIND OF LARGE INDUSTRIAL REGIONS. FREQUENTLY, CONTROL STRATEGIES SUCH AS THE USE OF VERY TALL STACKS, THROUGH WHICH INCREASED EMISSIONS BECAME ALLOWABLE, CONTRIBUTED TO THE WORSENING OF REGIONAL SCALE PROBLEMS.

THE FOLLOWING IS A DESCRIPTION OF HOW ONTARIO'S STUDIES HAVE ESTABLISHED THAT EMISSIONS IN THE EASTERN UNITED STATES, INCLUDING THE STATE OF MICHIGAN, CONSTITUTE A MAJOR CONTRIBUTION TO ONTARIO'S POLLUTION PROBLEMS.

ONTARIO HAS AIR MASSES MOVING INTO IT FROM ALL DIRECTIONS DEPENDING ON THE SYNOPTIC CONDITIONS. SOME OF THESE LEAD TO THE TRANSBOUNDARY TRANSPORT OF POLLUTANTS CONTRIBUTING TO THE DEVELOPMENT OF AIR POLLUTION EPISODES IN ONTARIO. AN EXAMPLE OF SUCH AN EPISODE OCCURRED DURING THE PERIOD OF FEBRUARY 19 TO 21, 1979.<sup>3</sup> THE SERIES OF WEATHER MAPS FOR THESE DAYS (FIGURES 4.1 TO 4.3) SHOW A HIGH PRESSURE AREA LOCATED SOUTH OF THE GREAT LAKES ON THE 19TH THAT MOVED EASTWARD TO OFF THE ATLANTIC COAST ON THE 21ST. THE SOUTHERLY CIRCULATION BACK-OF-THE HIGH CARRIED WITH IT SULPHUR DIOXIDE AND PARTICULATE MATTER INCLUDING SULPHATES INTO ONTARIO. ONTARIO'S POLLUTION INDEX, WHICH IS BASED ON THESE POLLUTANTS, REACHED HIGH LEVELS WHERE IT WAS MEASURED, EXCEEDING 32 IN SARNIA (MAX. 43), HAMILTON (MAX. 34) AND TORONTO (MAX. 33). INDUSTRIES IN THESE LOCATIONS WERE ASKED TO CURTAIL EMISSIONS TO PREVENT THE POLLUTION FROM REACHING HEALTH AFFECTING LEVELS, I.E. ABOVE 57.

USING BACK TRAJECTORY ANALYSES AND THE MEASUREMENTS OF POLLUTANTS AT RURAL LOCATIONS NEAR THE BOUNDARY, THE DATA INDICATED THAT A LARGE PROPORTION OF THE POLLUTION WAS TRANSPORTED INTO THE PROVINCE FROM THE UNITED STATES.

BACK TRAJECTORY ANALYSIS IS THE NAME GIVEN TO A PROCEDURE BY WHICH AIR PARCELS ARE FOLLOWED BACKWARD IN TIME TO DETERMINE THE ORIGIN AND TRACK THAT THE AIR PARCEL HAS TAKEN. FIGURES 4.4, 4.5 and 4.6 SHOW THE AIR PARCEL TRAJECTORIES TERMINATING AT LOCATIONS IN ONTARIO AT 1:00 A.M. ON THE 19TH, 20TH AND 21ST. THESE SHOW THAT THE AIR HAD PASSED ACROSS THE HIGHLY INDUSTRIALIZED MIDWESTERN STATES THAT HAVE MANY COAL-FIRED POWER PLANTS. THIS IS NOT AN ISOLATED INCIDENT. DURING THE PERIOD 1976 TO 1980 THERE HAVE BEEN 15 SUCH MAJOR INCIDENTS OF HIGH SULPHATES IN ONTARIO RESULTING FROM A BACK-OF-A-HIGH PRESSURE AREA SOUTHERLY CIRCULATION.

IMPACTS OF THE TRANSPORTED POLLUTANTS ARE THE RESULT OF THEIR ATMOSPHERIC DEPOSITION BY VARIOUS WET AND DRY MEANS. DATA FROM PRECIPITATION COLLECTORS OPERATED IN THE DORSET AREA OVER ALMOST A THREE YEAR PERIOD, COMBINED WITH BACK TRAJECTORY ANALYSES,<sup>1</sup> SHOWED THAT ABOUT 75% OF THE PRECIPITATION EVENTS AND MOREOVER, APPROXIMATELY 80% OF THE WET ACIDIC DEPOSITION AT THIS SITE, WERE ASSOCIATED WITH AIR MASSES ARRIVING FROM THE SOUTH AND SOUTHWEST. COMPARATIVELY, A SMALL PERCENTAGE OF THE LOADINGS CAME FROM THE NORTH AND NORTHWEST WHERE MAJOR ONTARIO SOURCES ARE LOCATED.

WHILE BACK TRAJECTORY ANALYSIS CAN TELL US THE DIRECTION FROM WHICH THE AIR HAS ORIGINATED, IT CANNOT QUANTIFY THE AMOUNT OR PERCENTAGE OF CONTRIBUTION THAT INDIVIDUAL SOURCES OR AGGREGATES OF SOURCES HAVE ON A RECEPTOR AREA. FOR SUCH AN ANALYSIS, ONTARIO UTILIZES COMPUTER MODELS WHICH SIMULATE THE ATMOSPHERE AND THE BEHAVIOUR OF POLLUTANTS EMITTED INTO IT.

UNTIL A FEW YEARS AGO, ENVIRONMENTALISTS WERE PRIMARILY CONCERNED WITH AIR QUALITY IN THE VICINITY OF A POLLUTANT SOURCE. CONCENTRATIONS WERE CONSIDERED HIGH IF THEY WERE ABOVE LEVELS DETERMINED TO BE HARMFUL TO PLANTS AND HUMAN HEALTH. USING THIS CRITERION, EVEN LARGE POLLUTANT SOURCES COULD BE CONSIDERED TO HAVE LITTLE EFFECT BEYOND DISTANCES OF THE ORDER OF TENS OF KILOMETRES FROM THE SOURCE. THIS WAY OF LOOKING AT POLLUTION IGNORED THE EFFECTS OF THE LARGE FRACTION OF THE EMISSIONS WHICH LEFT THIS REGION OF "LOCAL" AIR QUALITY EFFECTS AND THE ULTIMATE FORMATION OF SECONDARY POLLUTANTS DUE TO CHEMICAL TRANSFORMATIONS.

IT IS TO BE NOTED THAT, BY APPLYING THE CONVENTIONAL SHORT RANGE MODELS RECOMMENDED BY EPA, ALL THE POLLUTANTS ESCAPE TO GREATER DISTANCES, ALTHOUGH IN SMALL CONCENTRATIONS. IF WE APPLY DRY AND WET DEPOSITION TO THE PLUME, THEN APPROXIMATELY 30 - 90% OF THE POLLUTANTS WOULD ESCAPE TO GREATER DISTANCES DEPENDING ON THE PLUME ELEVATION. THIS IS ASSUMING THAT 10% OF THE TIME THE PLUME ENCOUNTERS PRECIPITATION AT THE RELEASE POINT.

IT IS ONLY RECENTLY THAT KNOWLEDGE OF THE CUMULATIVE EFFECT OF SMALL CONCENTRATIONS FROM A LARGE NUMBER OF SOURCES HAS BECOME COMMONPLACE. SECONDARY POLLUTANTS FROM SEVERAL SOURCES CAN BE HIGH AT DISTANCES OF HUNDREDS OF KILOMETRES FROM THE SOURCE REGION. FURTHERMORE, THE OCCURRENCE OF ACIDIC RAIN HAS FORCED US TO REDEFINE THE MEANING OF "HIGH" AS APPLIED TO LOCAL AIR QUALITY.

ANALYSIS OF METEOROLOGY DURING HIGH TOTAL SUSPENDED PARTICULATES EPISODES HAS SHOWN THE ROLE OF LONG RANGE TRANSPORT. MATHEMATICAL MODELLING HAS ALSO INDICATED THE EXTENT OF POLLUTION CAUSED BY LONG RANGE TRANSPORT. THESE MODELS ALSO DETERMINE THE SOURCE-RECEPTOR RELATIONSHIPS AND DEVELOP EMISSION CONTROL STRATEGIES.

IN RESPONSE TO THESE EVOLVING NEEDS, ONTARIO HAS DEVELOPED AN INTERNATIONALLY RESPECTED LONG RANGE TRANSPORT MODEL WHICH CALCULATES THE CONTRIBUTION OF SULPHUR DEPOSITION FROM THE EMITTING SOURCES.<sup>5</sup> THESE HAVE BEEN COMPUTED ON A PERCENTAGE BASIS FOR RECEPTOR AREAS IN BOTH CANADA AND THE UNITED STATES WHICH ARE SENSITIVE TO ACIDIC DEPOSITION. ONTARIO HAS USED THE RESULTS OF THIS MODEL IN MAKING THE DECISIONS FOR THE CONTROL OF ONTARIO'S MAJOR SO<sub>2</sub> EMITTERS AND FOR THE DETERMINATION OF THE IMPACT OF SOURCES THAT ARE LOCATED IN THE EASTERN UNITED STATES AND NEIGHBOURING PROVINCES. ALSO, THE MODEL HAS BEEN USED AS A GUIDELINE TO PREDICT WHAT WILL HAPPEN IF SOURCES IN THE MIDWESTERN UNITED STATES HAVE THEIR STATE IMPLEMENTATION PLAN (SIP) LIMITS RELAXED.<sup>2</sup>

THE SPECIFIC IMPACT OF THE MONROE POWER PLANT, WHICH IN 1979 EMITTED 264.9 THOUSAND TONNES OF SO<sub>2</sub>, IS SHOWN IN FIGURES 4.7 AND 4.8. IT IS NOTED THAT THE PERCENTAGE OF THE TOTAL WET DEPOSITION OF SULPHUR WHICH IS CONTRIBUTED BY MONROE IS A FUNCTION OF THE RECEPTOR LOCATION AND IS APPROXIMATELY 1% AT THE MUSKOKA-HALIBURTON AREA OF ONTARIO, AND 0.5% FOR THE UPPER PENINSULA OF THE STATE OF MICHIGAN.

COMPUTED AS A PERCENTAGE RELATIVE TO MICHIGAN AS A SOURCE AREA, MONROE'S CONTRIBUTION TO MUSKOKA-HALIBURTON AND THE UPPER PENINSULA IS APPROXIMATELY 10%.

THIS CONTRIBUTION TO WET SULPHUR DEPOSITION BY MONROE CAN BE CONSIDERED SIGNIFICANT AS IT IS ONE OF THE LARGEST OF THE HUNDREDS OF SO<sub>2</sub> SOURCES LOCATED IN THE NORTHEASTERN UNITED STATES AND CANADA.

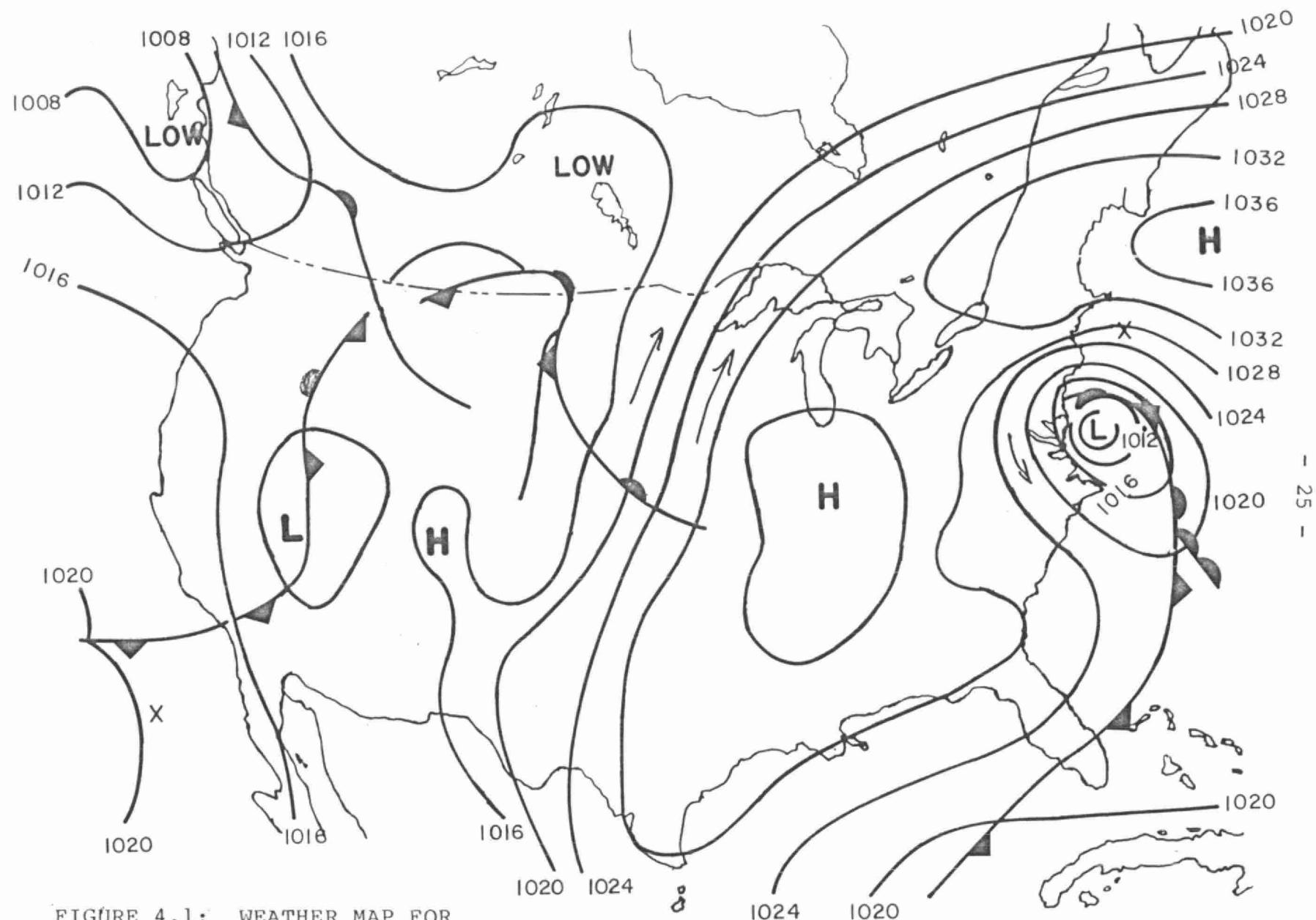


FIGURE 4.1: WEATHER MAP FOR  
MONDAY, FEBRUARY 19, 1979.

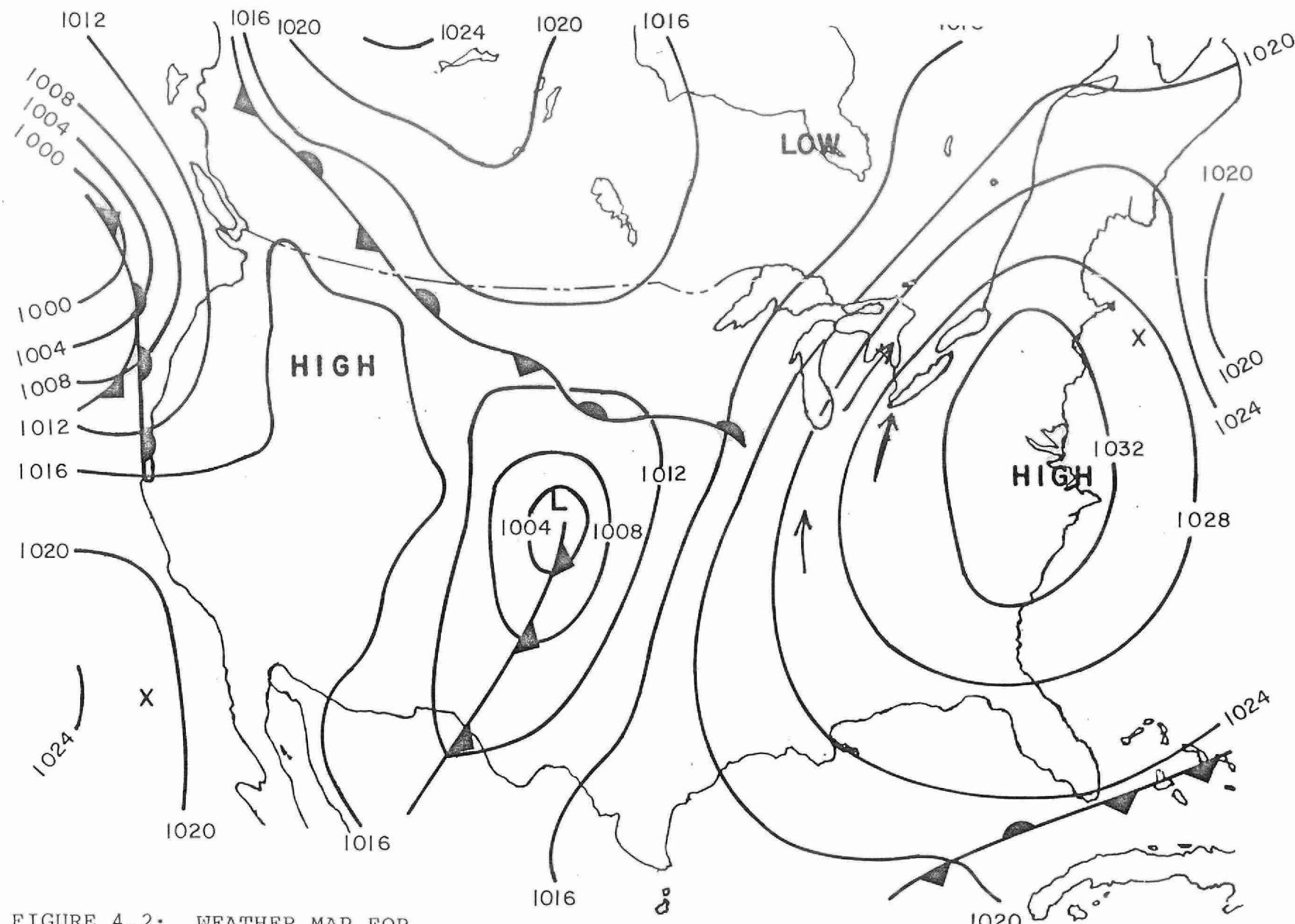


FIGURE 4.2: WEATHER MAP FOR  
TUESDAY, FEBRUARY 20, 1979.

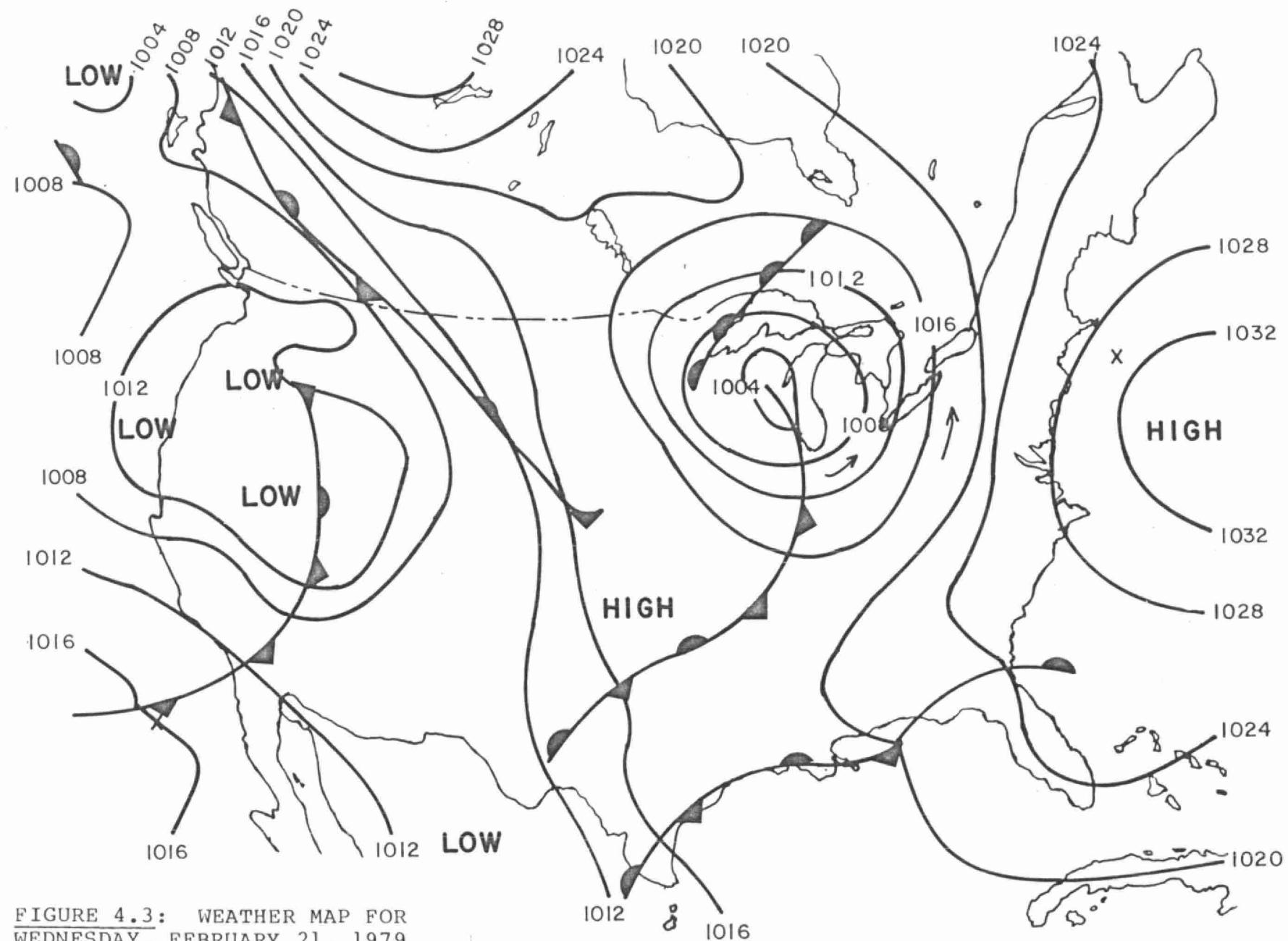
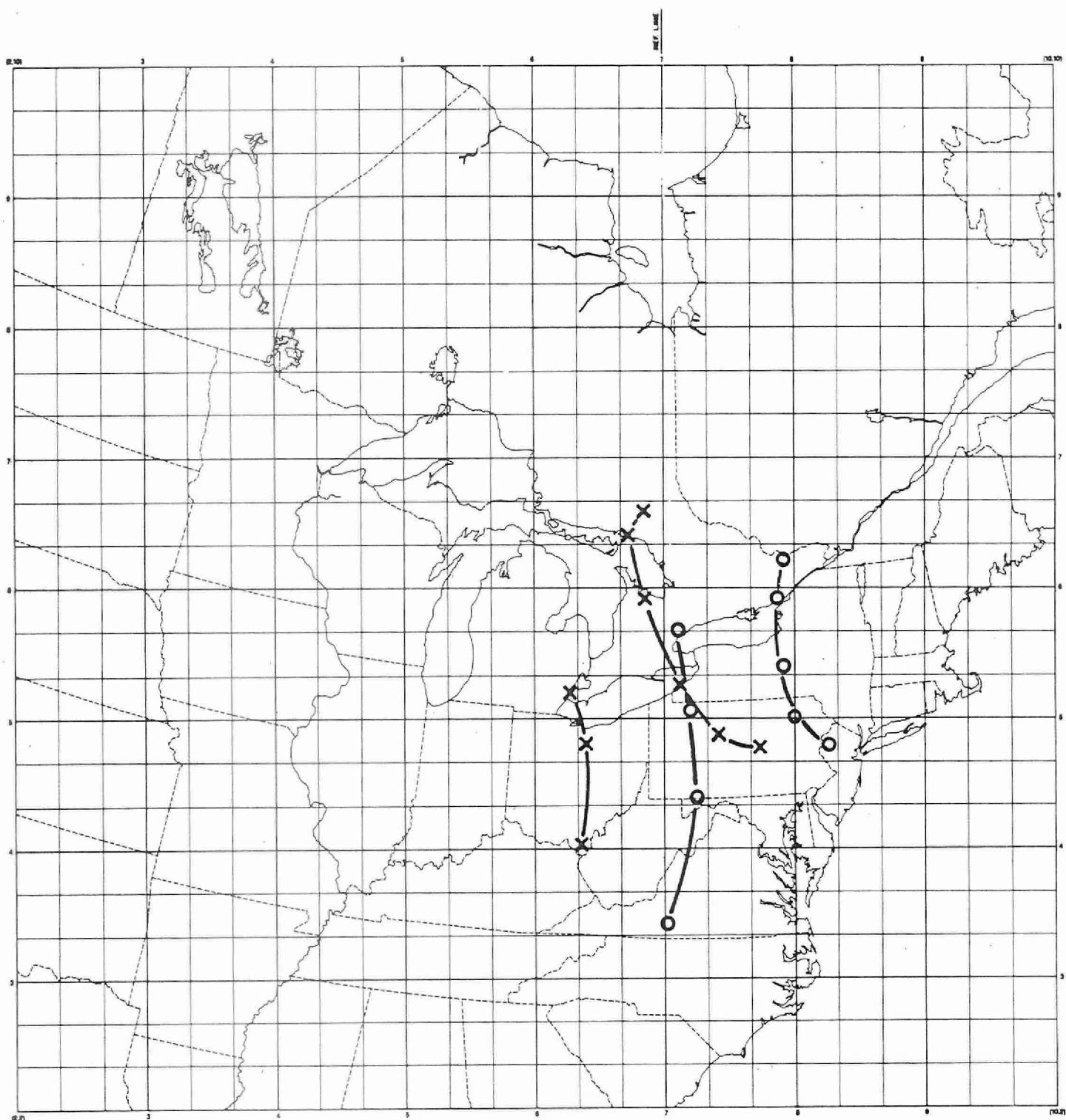
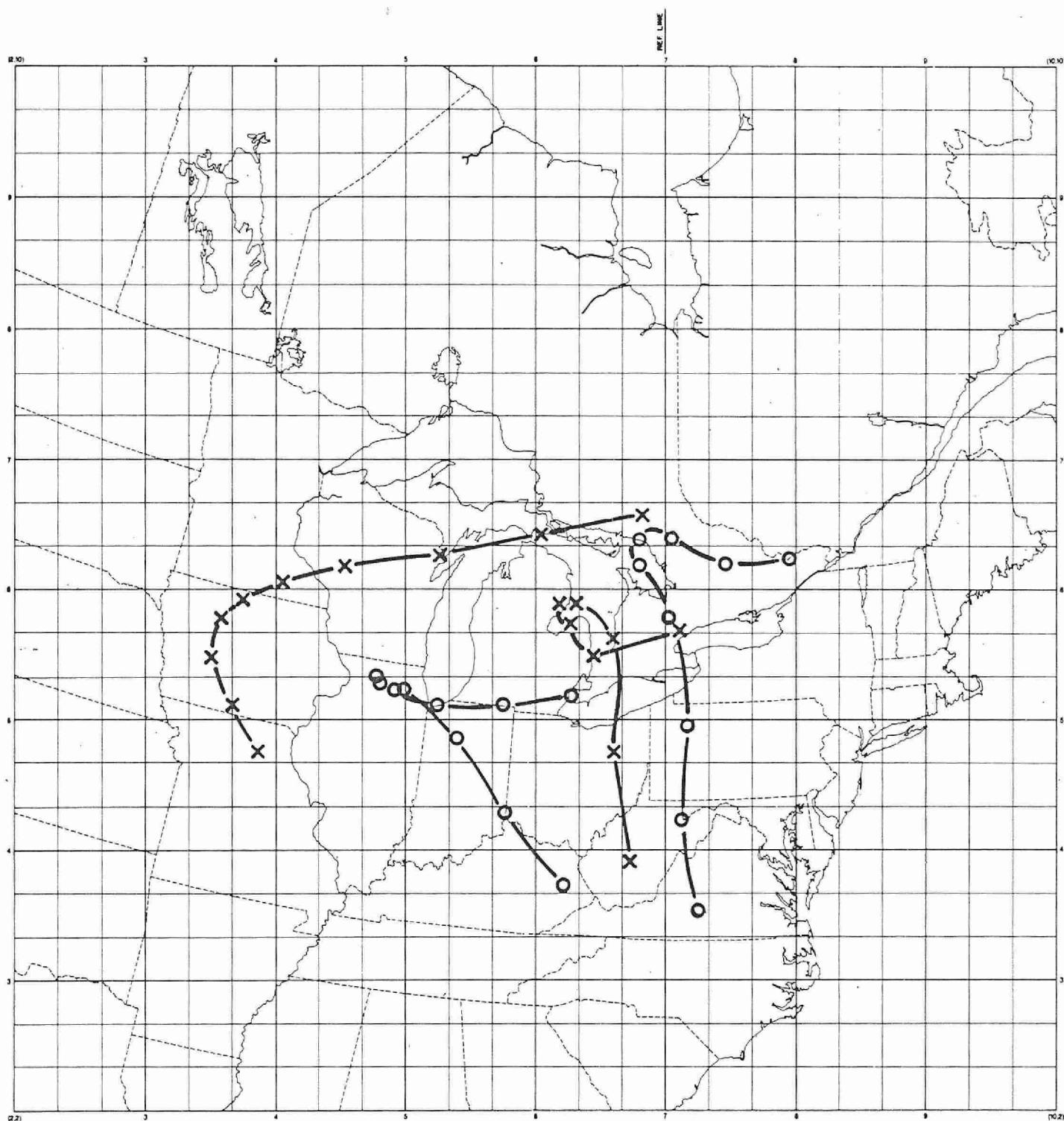


FIGURE 4.3: WEATHER MAP FOR  
WEDNESDAY, FEBRUARY 21, 1979.



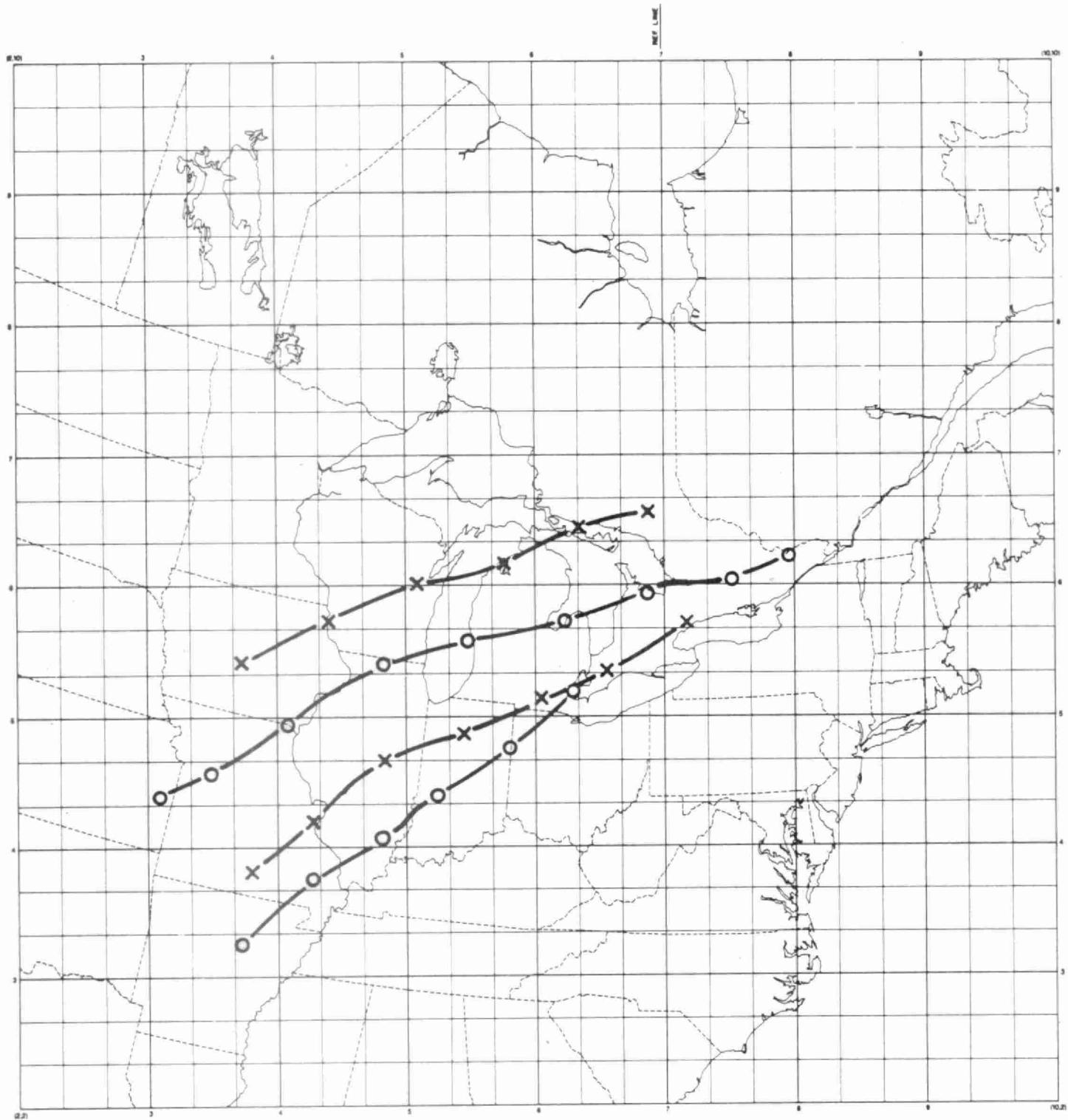
Back-trajectories showing Estimated Air Parcel locations at 6 hour Intervals Terminating at 0100 EST  
Feb. 19/79

FIGURE 4.4



Back-trajectories showing Estimated Air Parcel locations at 6 hour intervals Terminating at 0100 EST Feb. 20/79

FIGURE 4.5



Back-trajectories showing Estimated Air Parcel locations at 6 hour intervals Terminating at 0100 EST  
Feb. 21/79

FIGURE 4.6

## MONROE POWER PLANT

### Deposition of wet sulphur over total wet sulphur in percentage

BASE CASE 1979 EMISSION 0.2 BKGND ON SWET

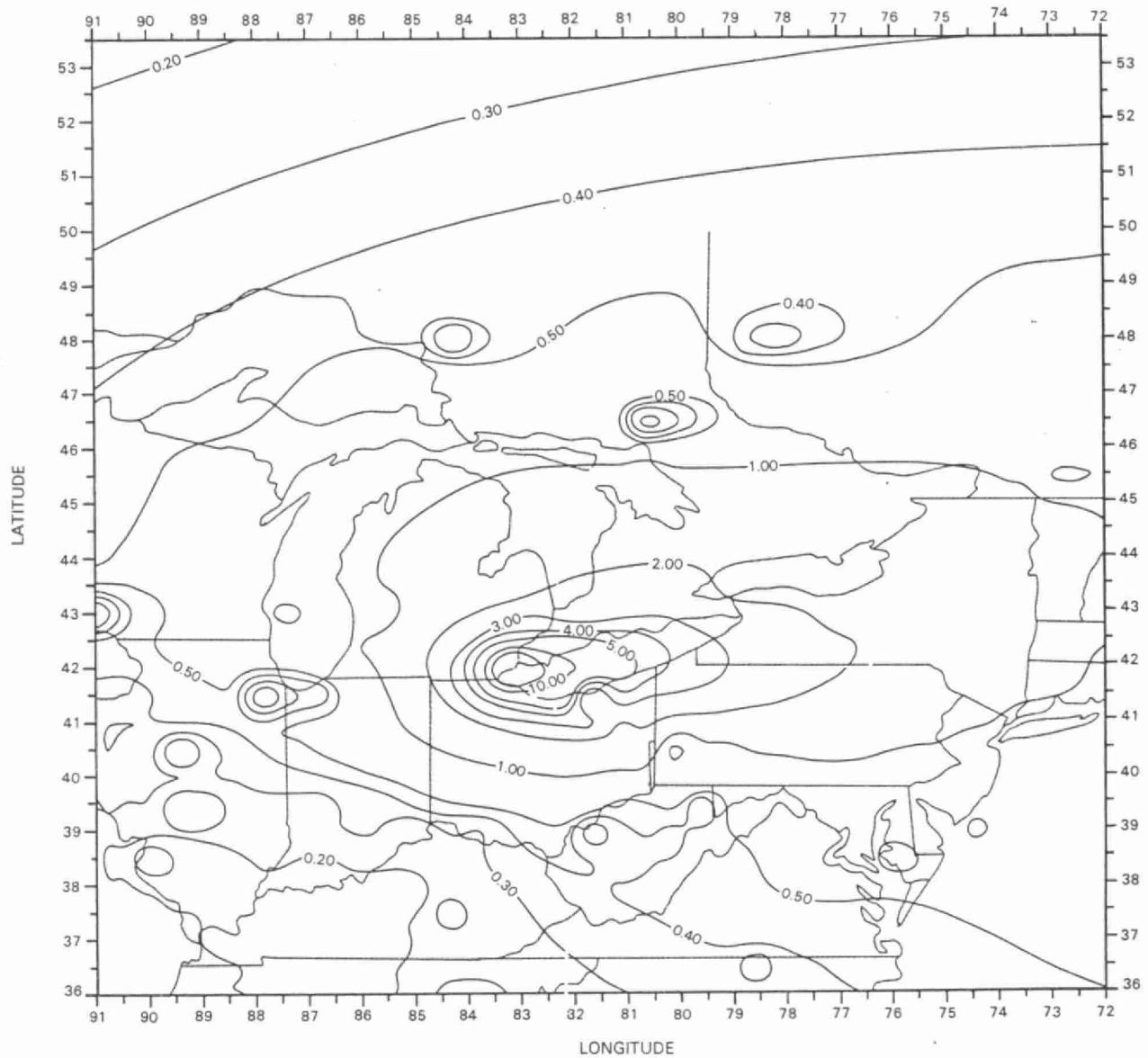


FIGURE 4.7

## MONROE POWER PLANT RELATIVE TO MICHIGAN STATE EMISSION

Deposition of wet sulphur over total wet sulphur  
in percentage

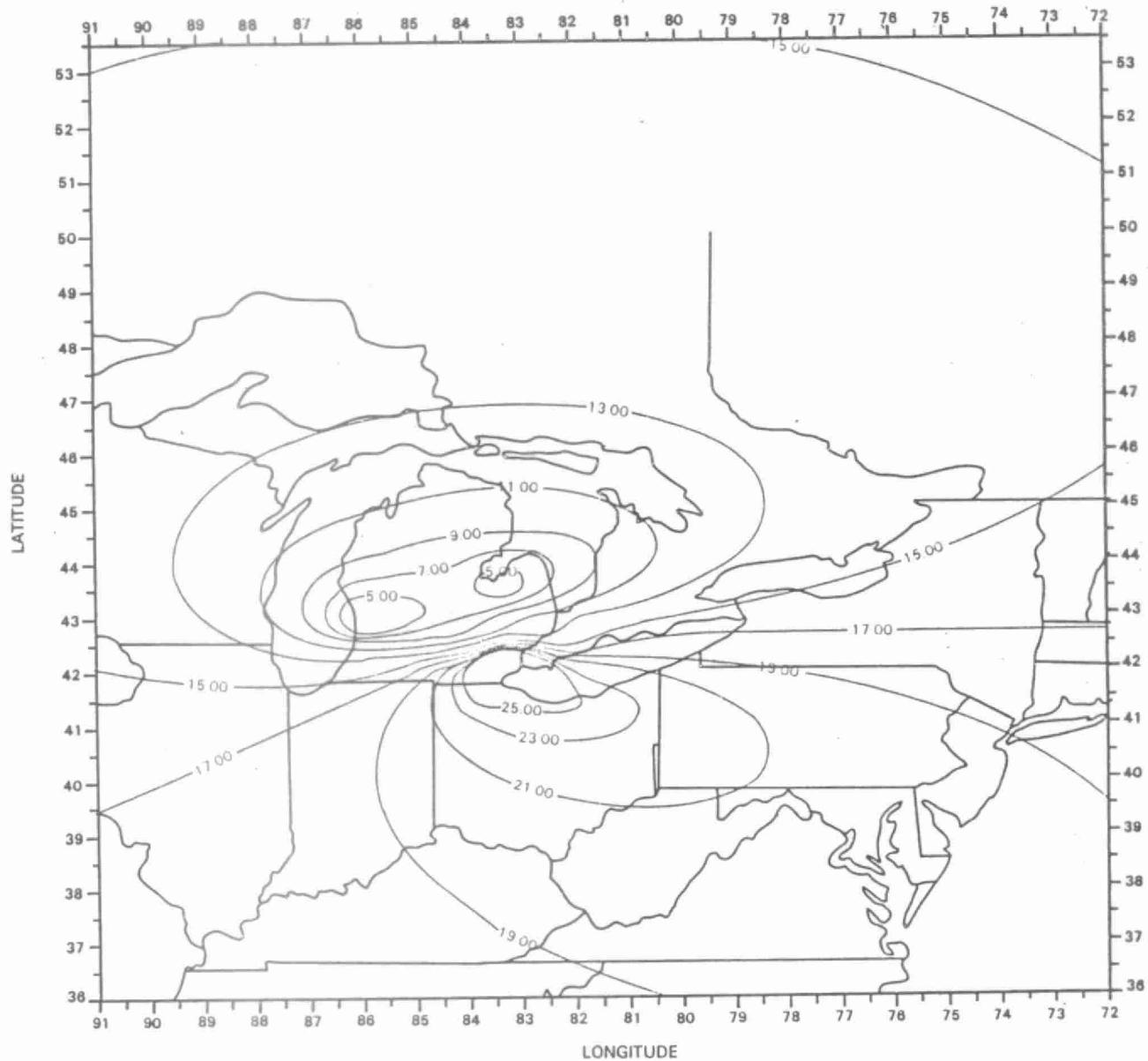


FIGURE 4.8

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## 5. EFFECTS OF ACIDIC DEPOSITION ON AQUATIC RESOURCES

SENSITIVE AQUATIC SYSTEMS WHICH RECEIVE ACID, BOTH DIRECTLY AND INDIRECTLY FROM PRECIPITATION, CAN SUFFER CHEMICAL AND BIOLOGICAL DAMAGES. THIS CHAPTER DISCUSSES THE NATURE AND MAGNITUDE OF THESE EFFECTS IN ONTARIO AS EVIDENCED THROUGH RESEARCH ON THE PROVINCE'S AQUATIC ECOSYSTEMS. A BRIEF STATEMENT ON AQUATIC RESOURCES AT RISK IN MICHIGAN IS INCLUDED.

### 5.1 GENERAL NATURE OF THE LAKE AND RIVER ACIDIFICATION PROCESS

ACIDS FALLING ON THE EARTH'S SURFACE MAY BE NEUTRALIZED BY CHEMICAL REACTION WITH BASIC MATERIALS IN THE SOIL AND WATER. AREAS UNDERLAIN BY ROCK CONTAINING LARGE AMOUNTS OF BASIC MATERIAL (SUCH AS LIMESTONE) CAN NEUTRALIZE THE ACIDS FOR INDEFINITE PERIODS OF TIME WITH ONLY MINOR CHANGES IN THE CHEMICAL COMPOSITION OF THE RUNOFF. IF, HOWEVER, THE SOILS AND BEDROCK HAVE LITTLE CAPACITY TO NEUTRALIZE THE ACID (FOR EXAMPLE, THE SPARINGLY SOLUBLE ROCKS OF THE PRECAMBRIAN SHIELD), THE ACID LOADING CAN EXCEED THE NEUTRALIZING CAPACITY AND RUNOFF WATER WILL BE ACIDIC WITH CONSEQUENTIAL BIOLOGICAL DAMAGE IN STREAMS AND LAKES.

THE ALKALINITY OF LAKE AND RIVER WATER IS A CHEMICAL MEASURE OF ITS CAPACITY TO NEUTRALIZE ACID AND IS COMMONLY REFERRED TO AS THE BUFFERING CAPACITY. THE GREATER THE ALKALINITY, THE GREATER THE CAPACITY TO NEUTRALIZE ACID. LAKES IN AREAS OF CALCAREOUS (LIMESTONE) SOILS HAVE HIGH ALKALINITIES AND pH VALUES GENERALLY ABOVE 7.0. BY CONTRAST, UNPOLLUTED LAKES LOCATED IN HARD ROCK GEOLOGICAL CONDITIONS (SUCH AS THE PRECAMBRIAN SHIELD AREA OF ONTARIO) HAVE LOW ALKALINITIES AND pH VALUES GENERALLY IN THE RANGE OF 6.0 TO 7.0. WHILE THESE LAKES ARE ON THE ACIDIC SIDE OF pH 7.0, THEY STILL HAVE HEALTHY AQUATIC LIFE.

LAKES WITH LOW ALKALINITY ARE REGARDED AS SENSITIVE TO THE EFFECTS OF ACIDIC RAIN SINCE THEY HAVE A LOW CAPACITY TO MAINTAIN (OR BUFFER) THE pH AT ACCEPTABLE VALUES WHEN EXCESSIVE ACID IS ADDED FROM THE ATMOSPHERE.

WHEN EXCESSIVE ACID LOADINGS FROM THE ATMOSPHERE ARE APPLIED TO SENSITIVE AREAS, THE pH OF THE RUNOFF MAY BE REDUCED TO VALUES WELL BELOW 6.0 FOR A FEW WEEKS TIME DURING SPRING SNOW MELT OR FOR A FEW HOURS OR DAYS DURING HEAVY SUMMER AND AUTUMN RAINS. LAKES WHICH SUFFER SHORT TERM pH DEPRESSION OR HAVE THEIR SUMMER pH VALUES SLIGHTLY REDUCED ARE CALLED "ACID STRESSED" LAKES.

OVER TIME, THE ACID LOADING CAN VIRTUALLY EXHAUST THE NEUTRALIZING (OR BUFFERING) CAPACITY OF THE SOILS IN

SENSITIVE AREAS AND THE RUNOFF CAN BECOME NEARLY AS ACIDIC AS THE RAINFALL ITSELF. WHEN THE ALKALINITY OF STREAMS AND LAKES FALLS TO ZERO (pH 4.5-5.0), THE WATERBODY IS CALLED "ACIDIFIED". AT THESE pH LEVELS, FISH POPULATIONS ARE SEVERELY STRESSED AND WILL BE LOST EVENTUALLY.

THEREFORE, THE ULTIMATE RESULT OF DEPOSITION OF ACIDS IN SENSITIVE AREAS IS ACIDIFICATION OF THE SURFACE WATER WITH LOSS OF FISH POPULATIONS AND CONCOMITANT DAMAGE TO OTHER AQUATIC LIFE FORMS. THESE EFFECTS HAVE BEEN WELL ESTABLISHED FOR LAKES AND RIVERS IN SCANDINAVIA AND THE ADIRONDACK MOUNTAINS AFFECTED BY ACIDIC DEPOSITION.<sup>41</sup>

## 5.2 AQUATIC EFFECTS IN MICHIGAN

WHILE IT IS NOT THE INTENT OF ONTARIO TO PRESENT A DETAILED CASE ON ACIDIC DEPOSITION AND ITS EFFECTS ON THE AQUATIC RESOURCES OF MICHIGAN, ONTARIO SUBMITS THAT EMISSIONS FROM THE MONROE PLANT CONTRIBUTE TO WET SULPHUR DEPOSITION, A SURROGATE OF ACIDIC DEPOSITION, IN THE STATE OF MICHIGAN (FIGURES 4.7 AND 4.8). THE LEGISLATIVE OFFICE OF THE SCIENCE ADVISOR OF THE STATE OF MICHIGAN HAS RECOGNIZED THAT "ACID RAIN IS A PROBLEM CONTINUOUSLY GROWING IN SERIOUSNESS IN MICHIGAN..."<sup>16</sup>

SEVERAL RESEARCHERS HAVE REPORTED THAT AREAS IN THE WESTERN PORTION OF THE UPPER PENINSULA OF MICHIGAN ARE SENSITIVE TO ACIDIC DEPOSITION.<sup>21, 29, 30</sup> THE CURRENT MEAN ANNUAL pH OF PRECIPITATION IN THE UPPER PENINSULA RANGES FROM 4.3 IN THE EASTERN END TO 4.6 IN THE WESTERN END,<sup>7</sup> VALUES WHICH ARE 20 TIMES AND 10 TIMES MORE ACIDIC THAN "NORMAL" PRECIPITATION OF pH 5.6 RESPECTIVELY.

DOHRENWEND ET AL (1980)<sup>18</sup> REPORTED SNOWFALL pH VALUES AS LOW AS 3.9 IN THE KEWEENAW PENINSULA IN MARCH 1978. CLEARLY, THERE ARE AREAS OF THE STATE WHERE ACIDIC PRECIPITATION COULD HAVE SERIOUS EFFECTS.

IT HAS BEEN ESTIMATED THAT THE WESTERN PORTION OF THE UPPER PENINSULA OF MICHIGAN HAS SOME 8,000 LAKES AND PONDS, OF WHICH MORE THAN 50% HAVE ALKALINITIES IN THE RANGE OF 10 MG L<sup>-1</sup> INDICATING SUSCEPTIBILITY TO ACIDIFICATION.<sup>40</sup> THE EFFECTS OF SURFACE WATER ACIDIFICATION IN MICHIGAN STREAMS HAS BEEN ADDRESSED BY BURTON ET AL (1981a, 1981b)<sup>11, 12</sup> IN WORK USING ARTIFICIAL STREAM CHANNELS SIMULATING ACTUAL STREAM CHEMISTRY. THE EFFECTS OF ACIDIC DEPOSITION ON THE RESOURCES OF MICHIGAN ARE OF SUFFICIENT CONCERN THAT RESEARCH IS BEING CONDUCTED BY SEVERAL AGENCIES INCLUDING U.S. EPA (ERL-DULUTH), U.S. DEPARTMENT OF AGRICULTURE (NADP), U.S. NATIONAL PARK SERVICE ON ISLE ROYALE, MICHIGAN DEPARTMENT OF NATURAL RESOURCES, MICHIGAN STATE UNIVERSITY, MICHIGAN TECHNOLOGICAL UNIVERSITY AND GENERAL MOTORS RESEARCH LABS.<sup>16</sup>

## 5.3 AQUATIC EFFECTS IN ONTARIO

### 5.3.1 RESEARCH APPROACH TO AQUATIC EFFECTS

UNDER THE CURRENT PATTERNS OF ACIDIC PRECIPITATION, VIRTUALLY ALL OF THE LAKES LOCATED IN PRECAMBRIAN ROCK IN ONTARIO ARE BEING SUBJECTED TO ACID LOADINGS ABOVE "BACKGROUND" LEVELS. PRECIPITATION WITH pH NEAR 5.6, THE VALUE EXPECTED FOR EQUILIBRIUM WITH ATMOSPHERIC CARBON DIOXIDE, CONTAINS ABOUT 2.5  $\mu$ EQ/L OF ACID (HYDROGEN ION). THE OBSERVED CONCENTRATIONS IN BULK DEPOSITION ARE ABOUT 11  $\mu$ EQ/L AT KENORA\* (4 TIMES THE "BACKGROUND" LEVEL<sup>37</sup>) AND UP TO 70-90  $\mu$ EQ/L IN THE IMPORTANT RECREATIONAL AREAS OF MUSKOKA-HALIBURTON\*\* (28-36 TIMES THE "BACKGROUND" LEVEL<sup>35</sup>). FOR SEVERAL YEARS, ENVIRONMENTAL STUDIES HAVE BEEN UNDERTAKEN IN THESE AREAS DESIGNED TO DETERMINE THE RESULTING WATER QUALITY AND BIOLOGICAL RESPONSES IN THE LAKES AND STREAMS. DATA PRESENTED IN THIS SECTION ARE DERIVED FROM THESE STUDIES.

\* LOCATED IN NORTHWEST ONTARIO, NORTHEAST OF THE ONTARIO-MINNESOTA BORDER. AREA CODE 2, MAP 5.1.

\*\* LOCATED IN SOUTH - CENTRAL ONTARIO. AREA CODE 1, MAP 5.1.

THE LAKES, RIVERS AND WATERSHEDS THEMSELVES ARE THE ULTIMATE "COLLECTORS" OF ATMOSPHERIC POLLUTION DEPOSITED BY WET AND DRY MECHANISMS. ONE RESEARCH APPROACH CONSIDERS LAKES AND WATERSHEDS IN THIS MANNER, AND HAS LED TO ESTABLISHING "CALIBRATED WATERSHEDS", WHICH ARE COMBINATIONS OF WATERSHEDS, STREAMS AND LAKES UNDER INTENSIVE MEASUREMENT. THIS APPROACH IS AN ESTABLISHED RESEARCH TOOL AND WAS USED IN THE DEVELOPMENT OF STRATEGIES FOR THE MANAGEMENT BY PHOSPHORUS CONTROL, OF LAKES AFFECTED BY EUTROPHICATION. THE CALIBRATED WATERSHED STUDIES ARE PRIME SOURCES OF INFORMATION ON ACID RAIN EFFECTS.

HYDROLOGIC WEIRS (FIGURE 5.1) ARE SET UP ON THE STREAMS ENTERING AND LEAVING A PARTICULAR STUDY LAKE. THE FLOWS OF WATER AND DISSOLVED SUBSTANCES ARE ACCURATELY MEASURED AND COMBINED WITH THE BEST POSSIBLE MEASURES OF ATMOSPHERIC INPUTS AND OF WATER LOSS BY EVAPORATION TO CALCULATE "SUBSTANCE BUDGETS".

THE DIFFERENCE BETWEEN THE INPUTS MEASURED BY THE BUDGETS AND THE INPUTS MEASURED FROM WET DEPOSITION CAN BE USED TO COMPUTE ESTIMATES OF DRY DEPOSITION.

THE CALIBRATED WATERSHEDS ARE SUBJECTED TO DETAILED CHEMICAL AND BIOLOGICAL SAMPLING AND THUS SERVE TO QUANTIFY THE CHEMICAL AND BIOLOGICAL EFFECTS OF POLLUTANT DEPOSITION. RELATIONSHIPS ESTABLISHED BY DETAILED STUDIES CAN BE EXTRAPOLATED TO LARGE NUMBERS OF LAKES FOR WHICH LESS COMPLETE DATA ARE AVAILABLE.

CALIBRATED WATERSHEDS HAVE BEEN ESTABLISHED AT MANY LOCATIONS (FIGURE 5.2) SUCH AS KENORA, SAULT STE. MARIE AND DORSET IN ONTARIO, LAURENTIDE PARK IN QUEBEC, KEJIMKUJIK PARK IN NOVA SCOTIA, HUBBARD BROOK IN NEW HAMPSHIRE, SAGAMORE LAKE IN NEW YORK AND COWEETA IN NORTH CAROLINA. FOR EACH STUDY SITE, A DATA BASE OF ATMOSPHERIC LOADINGS AND RESULTING AQUATIC AND TERRESTRIAL EFFECTS IS BEING COMPILED. CONCLUSIONS REGARDING EFFECTS ARE DRAWN FROM COMPARISONS BETWEEN AREAS AND FROM LONG TERM OBSERVATIONS IN EACH AREA. EXTENSIVE RESULTS FOR ONTARIO ARE AVAILABLE FROM THE KENORA AND DORSET STUDY LOCATIONS.

#### 5.3.2 OBSERVED EFFECTS ON WATER QUALITY

##### 5.3.2.1 SURFACE WATER QUALITY

MANY LAKES NEAR SUDBURY, ONTARIO HAVE BEEN ACIDIFIED BY ATMOSPHERIC DEPOSITION OF ACIDS.<sup>5,14</sup> THE PROBLEM WAS REGARDED AS "LOCAL" DUE TO EMISSIONS OF SULPHUR DIOXIDE FROM COPPER AND NICKEL SMELTERS. IT WAS ADDRESSED BY REDUCING EMISSIONS AND BY COMMISSIONING THE WORLD'S HIGHEST SMOKE STACK IN 1972 TO UTILIZE THE DILUTION CAPACITY OF THE ATMOSPHERE FOR THE LARGEST SINGLE SOURCES IN THE AREA. GROUND LEVEL SULPHUR DIOXIDE CONCENTRATIONS DUE TO THE LOCAL SOURCES HAD CAUSED DISCOMFORT TO PEOPLE AND DAMAGE TO VEGETATION AND BOTH PROBLEMS HAVE ESSENTIALLY BEEN ELIMINATED BY THE LOCAL EMISSIONS MANAGEMENT PROGRAMS.

THE SUDBURY SITUATION IS WELL KNOWN BECAUSE OF ITS SIZE, PARTICULARLY THE INCO LTD. SMELTER, BUT IT IS NOT UNIQUE. DURING THE 1970'S HUNDREDS OF OTHER PLANTS AND INDUSTRIES WERE BUILT IN THE UNITED STATES AND CANADA WHICH UTILIZED HIGH STACKS TO DISPERSE WASTES. EMISSION REDUCTIONS WERE SELDOM APPLIED; DILUTION BY THE ATMOSPHERE WAS EXPECTED TO SOLVE THE "PROBLEM".

THE OVERALL RESULT IS THAT TODAY, IN NORTH AMERICA, THERE ARE HUNDREDS OF SOURCES OF SULPHUR AND NITROGEN OXIDES FROM THE BURNING OF FOSSIL FUELS AND OTHER INDUSTRIES, INCLUDING NON-FERROUS SMELTING OPERATIONS, ALL DEPENDING ON ATMOSPHERIC DILUTION TO RESOLVE PART OF THE WASTE PROBLEM.

IN RECENT YEARS IT HAS BECOME WELL UNDERSTOOD THAT THE ACIDIC RAIN PROBLEM IN ONTARIO IS NOT CONFINED TO THE SUDBURY AREA<sup>17</sup> AND THAT THE SUDBURY SOURCES WERE ONLY A SMALL PART OF THE TOTAL EMISSIONS TO THE ATMOSPHERE LEADING TO ACIDIC DEPOSITION IN ONTARIO.

HISTORICAL EVIDENCE OF ACIDIFICATION IN OTHER AREAS OF ONTARIO IS DIFFICULT TO OBTAIN BECAUSE OF THE LIMITED AMOUNT OF BASELINE DATA. HOWEVER, ONE WELL DOCUMENTED CASE IS THAT OF CLEAR LAKE IN MUSKOKA-HALIBURTON. THE SUMMER ALKALINITY VALUE OF CLEAR LAKE WAS 33  $\mu$ EQ/L IN 1967 AND ONLY 2-15  $\mu$ EQ/L IN 1977 INCLUDING A NET LOSS OF

BUFFERING CAPACITY.<sup>17</sup> IN OTHER WORDS, THE LAKE IS ACID-STRESSED. THIS LAKE IS ONLY UNIQUE IN THAT ACCURATE HISTORICAL DATA WERE AVAILABLE. THERE IS NO REASON TO DOUBT THAT MANY OTHER SENSITIVE ONTARIO LAKES HAVE ALREADY SHARED THE SAME FATE AND THAT MANY THOUSANDS MORE WILL FOLLOW IN DUE COURSE IF NO ABATEMENT ACTION IS TAKEN.

TO ASCERTAIN THE GEOGRAPHICAL BREADTH OF THE PROBLEM, LAKE ALKALINITY VALUES WERE MEASURED ON SOME 2,619 LAKES IN VARIOUS AREAS OF THE PRECAMBRIAN SHIELD (TABLE 5.1).<sup>2</sup> THE NUMBER OF LAKES SAMPLED IN EACH AREA TO DATE IS SMALL IN COMPARISON TO THE TOTAL LAKES IN THESE AREAS, BUT BASED ON THIS DATA, IT IS BECOMING CLEAR THAT A HIGH PERCENTAGE OF THE LAKES IN THE ENTIRE PRECAMBRIAN SHIELD FALL IN THE EXTREMELY OR MODERATELY SENSITIVE CATEGORIES.

THE LAKES IN THE EXTREME SENSITIVITY CATEGORY ARE CURRENTLY ACID STRESSED AND ARE LIKELY TO BE ACIDIFIED BY LONG RANGE TRANSPORT IF CURRENT ACID LOADINGS CONTINUE. LOSS OF BUFFERING CAPACITY IS CUMULATIVE, ITS RATE AND TIMING DEPENDENT ON THE RATE OF DEPOSITION. ONCE LOST, THERE IS NOTHING TO PREVENT THE LAKE FROM QUICKLY ACIDIFYING. THIS SUPPOSITION IS SUPPORTED BY THE LONG TERM OBSERVATION OF LAKE ACIDIFICATION IN SCANDINAVIA<sup>9</sup> AND THE ADIRONDACKS.<sup>33</sup>

ON A SHORT-TERM OR EPISODIC BASIS, DETRIMENTAL WATER QUALITY EFFECTS ARE BEING OBSERVED NOW. IN BOTH AREAS OF ONTARIO INTENSIVELY STUDIED TO DATE, ACIDS (HYDROGEN IONS) FROM ATMOSPHERIC DEPOSITION ARE NEUTRALIZED DURING MOST OF THE YEAR. RETENTION (NEUTRALIZATION) OF HYDROGEN IONS HAS BEEN MEASURED AT 88% AND 98% ON AN ANNUAL BASIS AT KENORA AND DORSET RESPECTIVELY.<sup>26</sup> HOWEVER, THE HYDROGEN IONS STORED IN THE SNOWPACK ENTER STREAMS AND LAKES IN THE SPRING THAW AND MOST OF THE TOTAL ANNUAL ACID INPUT OCCURS DURING THE SPRING MELT. THE LARGE VOLUME OF WATER, COUPLED WITH LESS CHANCE FOR INTERACTION WITH THE FROZEN SOILS, RESULTS IN "SHOCK" LOADINGS OF ACID TO STREAMS AND THE SURFACE WATERS OF LAKES.

JEFFRIES ET AL<sup>28</sup> COMPARED pH VALUES OF A SERIES OF SMALL STREAMS AND LAKE OUTLETS MEASURED BEFORE AND DURING SPRING MELT AT DORSET (TABLE 5.2). THE LOWEST pH VALUES OBSERVED IN THE LAKE OUTLETS (4.8-5.0) ARE WITHIN THE RANGE CAPABLE OF CAUSING DAMAGE TO AQUATIC LIFE, PARTICULARLY FISH. AS MUCH AS 76.6% OF THE MEASURED YEARLY DISCHARGE OF ACID FROM THE WATERSHEDS OCCURRED IN APRIL. FIGURE 5.3 SHOWS A TYPICAL HYDROGRAPH FOR ONE OF THESE STREAMS, EMPHASIZING THE HIGH SPRING WATER FLOW, HIGH ACID DISCHARGE AND LOW pH VALUES. SCHEIDER ET AL<sup>36</sup> FURTHER OBSERVED THAT THE pH OF STREAMS WAS DEPRESSED FOR PERIODS OF A FEW HOURS DURING TIMES OF HEAVY RUNOFF AFTER SUMMER STORM EVENTS (FIGURE 5.4). HEAVY AUTUMN RAINS ALSO CAUSE DEPRESSED pH IN RUNOFF FOR A FEW DAYS AT A

TIME. IN ONE PARTICULAR YEAR OF STUDY, AS MUCH AS 25.8% OF THE TOTAL ANNUAL HYDROGEN ION RUNOFF FROM SMALL WATERSHEDS OCCURRED IN OCTOBER.

THERE ARE 32 CALIBRATED WATERSHEDS UNDER STUDY IN THE DORSET AREA AND SOME HAVE RESULTS FOR A PERIOD OF FIVE YEARS. THE RESULTS DESCRIBED HERE ARE TYPICAL OF THE FULL SET OF OBSERVATIONS AND IT CAN BE CONCLUDED THAT ATMOSPHERIC ACID LOADINGS ARE CAUSING PERIODIC WATER QUALITY CHANGES. THE STUDY LAKES ALL HAVE LOW ALKALINITIES BUT ARE REPRESENTATIVE OF THOUSANDS OF LAKES IN THE PRECAMBRIAN AREA.

IN ADDITION TO DIRECT EFFECTS ON SURFACE WATER pH, ACIDIC PRECIPITATION HAS THE POTENTIAL OF INCREASING THE LEACHING RATE OF MATERIAL FROM THE WATERSHED. ALUMINUM IS A MAJOR CONSTITUENT OF THE BEDROCK MATERIAL IN THE PRECAMBRIAN AREA AND IT TENDS TO BE DISSOLVED BY ACIDIC RUNOFF. SCHEIDER ET AL<sup>36</sup> REPORTED AN AVERAGE TOTAL ALUMINUM CONCENTRATION OF 49  $\mu\text{g}/\text{L}$  FOR THE STUDY LAKES AT DORSET. CONCENTRATIONS IN STREAMS ARE TYPICALLY UP TO 200-300  $\mu\text{g}/\text{L}$  WITH SOME MEASUREMENTS EXCEEDING 500  $\mu\text{g}/\text{L}$ , PARTICULARLY IN THE SPRING RUNOFF (SCHEIDER, PERS. COMM.).

LABORATORY EXPERIMENTS HAVE SHOWN THAT SURVIVAL OF BROOK TROUT WAS REDUCED TO LESS THAN 50% AFTER 14 DAYS AT ALUMINUM CONCENTRATIONS OF 420 AND 480  $\mu\text{g}/\text{L}$  AT pH VALUES OF 5.2 AND 4.4 RESPECTIVELY.<sup>19</sup>

IT APPEARS THAT THE pH AND ALUMINUM CONCENTRATIONS BEING OBSERVED IN THE DORSET STUDY LAKES DURING SPRING SNOW MELT FALL WITHIN THE RANGES WHICH LABORATORY EXPERIMENTS HAVE SHOWN TO BE LETHAL TO FISH.

### 3.2.2 GROUND WATER QUALITY

HULTBERG AND WENBLAD<sup>27</sup> HAVE IDENTIFIED A NUMBER OF SHALLOW WELLS IN SWEDEN WHICH HAVE BECOME ACIDIC AS A RESULT OF ACIDIC PRECIPITATION INFILTRATING SOILS WITH VERY LOW NEUTRALIZING CAPACITY. THE ACIDIC WATER HAS CAUSED SERIOUS CORROSION OF PLUMBING AND IN SOME CASES ENTIRE SYSTEMS OF COPPER PIPES HAVE HAD TO BE REPLACED AFTER 10 TO 15 YEARS OF USE. THE ACIDIC WELLS ARE CHARACTERIZED BY ROCK OUTCROPS ALLOWING SURFACE RUNOFF TO MOVE TO SANDY SUBSOIL WITH MINIMAL CONTACT WITH SURFACE SOILS. THERE IS LITTLE OPPORTUNITY FOR THE NEUTRALIZING CAPACITY OF THE SURFACE SOILS TO BE UTILIZED IN NEUTRALIZING THE RUNOFF.

MANY WELLS IN THE PRECAMBRIAN AREA OF NORTH AMERICA SERVICING SEASONAL COTTAGES AND PERMANENT HOMES ARE LOCATED IN SIMILAR GEOLOGICAL CONDITIONS SO THE POTENTIAL FOR ACIDIFICATION OF GROUND WATER EXISTS. THE FIRST FIELD SURVEYS WERE CARRIED OUT IN 1980 IN THE MUSKOKA-HALIBURTON AREA OF ONTARIO.<sup>38</sup> A TOTAL OF 89 GROUND WATER SAMPLES WERE ANALYZED FOR pH. GROUND WATER

WAS SAMPLED FROM SHALLOW SPRINGS AND AT VARIOUS DEPTHS IN WELLS OBTAINING WATER FROM BOTH BEDROCK AND OVERBURDEN FORMATIONS.

ELEVEN OF THE 89 SAMPLES HAD pH VALUES LESS THAN 6.0, WITH THE LOWEST VALUE BEING 5.2. SUBSEQUENT RESAMPLING (SUMMER, FALL) OF THE LOW pH VALUES RESULTED IN ONLY ONE SAMPLE STILL HAVING A pH OF LESS THAN 6.0.

### 5.3.3 OBSERVED EFFECTS ON AQUATIC BIOTA

#### 5.3.3.1 FISH

ALTHOUGH WATER QUALITY CHANGES ARE A CONCERN IN THEIR OWN RIGHT, IT IS THE BIOLOGICAL RESPONSES TO ACIDIFICATION WHICH ARE OF UPPERMOST IMPORTANCE. DAMAGE TO FISH POPULATIONS IS A MAJOR CONCERN AS IT REPRESENTS A LOSS TO THE SPORT FISHING INDUSTRY AND SERIOUS DISRUPTION OF THE BIOLOGICAL FOOD CHAIN SINCE SO MANY BIRDS AND MAMMALS DEPEND ON FISH FOR FOOD. COMPLETE LOSS OF FISH TENDS TO BE REGARDED AS THE DEFINITION OF A 'DEAD LAKE'.

THE REPORTED EFFECTS OF ACIDIFICATION ON FISH ARE MANY AND VARIED. HARVEY<sup>22</sup> REPORTED FISH KILLS IN PLASTIC LAKE IN HALIBURTON DURING THE SPRING MELT WHEN THE SURFACE WATER pH OF THE LAKE WAS 5.5 AND THE INLET STREAMS HAD A pH OF 3.8. FISH CAGING EXPERIMENTS IN THE SPRING OF 1981 (H. HARVEY, PERS. COMM.) CONFIRMED THE TOXIC NATURE

OF THE WATER, PARTICULARLY OF THE INLET STREAM (pH 4.0-4.1) WHERE 100% OF THE CAGED FISH DIED IN TWO DAYS. SHORTLY AFTER THE CAGING EXPERIMENT SCUBA DIVERS OBSERVED DEAD FISH IN THE LAKE AS WELL.

LOSS OF FISH POPULATIONS HAS BEEN DOCUMENTED FOR SEVERAL LAKES IN ONTARIO CONCURRENT WITH LAKE ACIDIFICATION.<sup>25</sup> THE MECHANISM OF EXTINCTION IS USUALLY FAILURE OF RECRUITMENT OF NEW AGE CLASSES INTO THE POPULATION, AS OBSERVED AT PATTEN LAKE (FIGURE 5.5).<sup>34</sup> ANOTHER PHENOMENON IN ACID-STRESSED LAKES IS LOSS OF OLDER FISH FROM THE POPULATION. FIGURE 5.6 ILLUSTRATES THE AGE DISTRIBUTION OF WHITE SUCKERS IN GEORGE LAKE NEAR SUDBURY DURING A 13 YEAR PERIOD WHILE THE LAKE WAS BECOMING ACIDIC.<sup>3, 4, 6, 24</sup> FIGURES 5.7 AND 5.8 SHOW AGE DISTRIBUTIONS OF WHITE SUCKER IN CROSSON, RED CHALK AND HARP LAKES IN MUSKOKA-HALIBURTON.<sup>23</sup> THE ACID-STRESSED CROSSON LAKE (pH 5.4-6.4) HAS AN AGE DISTRIBUTION SIMILAR TO GEORGE LAKE SHOWING THE SHIFT TO YOUNGER AGE CLASSES COMPARED TO THE NEUTRAL RED CHALK LAKE (pH 5.5-7.2) AND HARP LAKE (pH 5.8-7.0).

WHITE SUCKERS ARE AN IMPORTANT "TEST SPECIES" SINCE THEY ARE NOT SUBJECT TO FISHING PRESSURE AND THEREFORE, ANY CHANGES IN POPULATION ARE DUE TO ENVIRONMENTAL EFFECTS.

THESE OBSERVATIONS PROVIDE STRONG EVIDENCE THAT THE FISHERIES ARE BEGINNING TO SUFFER UNDER THE PRESENT ACID LOADING CONDITIONS. IT IS REASONABLE TO ASSUME THAT SIMILAR CHANGES ARE TAKING PLACE IN THE MANY THOUSANDS OF LAKES WITH SIMILAR ALKALINITIES WHICH ARE LIKELY EXPERIENCING SIMILAR WATER QUALITY EFFECTS.

#### 5.3.3.2 MERCURY IN FISH

SINCE ELEMENTAL, METALLIC MERCURY CAN EXIST IN THE GAS PHASE AT ORDINARY AIR TEMPERATURES IT HAS BECOME UBIQUITOUS IN THE ENVIRONMENT. LARGE QUANTITIES OF MERCURY PASS BETWEEN THE EARTH AND THE ATMOSPHERE BY NATURAL CYCLING PROCESSES WHICH HAVE BEEN GOING ON FOR MILLIONS OF YEARS. THEREFORE, THE MERE PRESENCE OF MERCURY IN ANY COMPARTMENT OF THE ENVIRONMENT DOES NOT NECESSARILY IMPLY ANY HUMAN INFLUENCE.

MAN'S PROPENSITY TO UTILIZE THE ATMOSPHERE FOR THE DISPOSAL OF WASTES INFLUENCES THE NATURAL MERCURY CYCLE IN TWO WAYS. FIRSTLY, MAN'S ACTIVITIES DIRECTLY INCREASE THE TOTAL AMOUNT OF MERCURY ENTERING THE ATMOSPHERE. SECONDLY, THE AMOUNT OF MERCURY IN FISH AND OTHER AQUATIC ORGANISMS IS INCREASED DUE TO THE ACIDIFICATION OF SURFACE WATERS BY ACIDIC DEPOSITION.

REGARDING THE FIRST INFLUENCE, IT HAS BEEN ESTIMATED THAT ON A GLOBAL SCALE HUMAN ACTIVITIES HAVE INCREASED THE MERCURY EMISSIONS TO THE ATMOSPHERE BY 27%<sup>31</sup> BUT IT IS NOT KNOWN HOW THIS INCREASE INFLUENCES THE GLOBAL MERCURY CYCLE. WITHIN EASTERN NORTH AMERICA, HOWEVER, THE SITUATION IS QUITE DIFFERENT. MAN-MADE MERCURY DISCHARGES TO THE ATMOSPHERE FROM THE U.S. STATES BORDERING ON THE GREAT LAKES ARE 170% OF THE NATURAL ATMOSPHERIC LOADING.<sup>31</sup> STATES FARTHER SOUTH WHICH MAY STILL INFLUENCE THE PRECAMBRIAN AREA BY LONG RANGE TRANSPORT HAVE SIMILAR MAN-MADE ATMOSPHERIC DISCHARGES.

COAL CONTAINS AN AVERAGE OF ABOUT 60 NG/G OF MERCURY<sup>15</sup> AND UP TO 97% MAY BE EMITTED FROM STACKS UPON COMBUSTION.<sup>8</sup> THE MEAN RESIDENCE TIME IN THE ATMOSPHERE HAS BEEN ESTIMATED TO BE 11 DAYS.<sup>31</sup> THEREFORE, THERE IS PLENTY OF TIME FOR LONG RANGE TRANSPORT PRIOR TO DEPOSITION. THESE POINTS ARE OF PARTICULAR CONCERN REGARDING ANY POLICY TO INCREASE THE USE OF COAL AS AN ENERGY SOURCE.

IF ALL OTHER FACTORS WERE EQUAL, ONE COULD EXPECT SUCH LARGE INCREASES IN ATMOSPHERIC EMISSIONS TO INCREASE THE DEPOSITION RATE AND HENCE, THE CONCENTRATIONS OF MERCURY IN LIVING ORGANISMS. HOWEVER, INCREASED DEPOSITION HAS NOT YET BEEN FULLY SUBSTANTIATED AS ATMOSPHERIC STUDIES ON MERCURY HAVE BEEN CARRIED OUT ONLY IN A PRELIMINARY WAY TO DATE.

THE SECOND FACTOR INFLUENCING THE NATURAL MERCURY CYCLE, IS ACIDIFICATION OF SURFACE WATERS. ACIDIFICATION OF LAKES TAKES PLACE OVER A TIME PERIOD MEASURED IN YEARS OR EVEN DECADES. DURING THIS TIME THERE STILL WILL BE FISH IN THE WATER ALTHOUGH THE AVERAGE pH OF THE WATER WILL BE DECLINING SLOWLY. IT HAS BEEN SHOWN THAT THE LOWER pH CONDITIONS TEND TO CAUSE INCREASES IN THE MERCURY CONCENTRATIONS IN FISH.<sup>20, 10, 1</sup> THE RESULT IS, THAT OVER A LONG PERIOD OF TIME, LAKES AND RIVERS SUBJECTED TO ACID STRESS STILL WILL HAVE SOME FISH BUT THE MERCURY CONCENTRATIONS IN THOSE FISH WILL INCREASE. BIRDS AND ANIMALS WHICH EAT FISH AS A MAJOR PART OF THEIR DIET WILL INGEST QUANTITIES OF MERCURY WHICH MAY WELL THREATEN THEIR HEALTH AND SURVIVAL.

SUNS<sup>39</sup> HAS BEEN SAMPLING YOUNG-OF-THE-YEAR AND YEARLING FISH FOR CONTAMINANT STUDIES. THIS APPROACH REDUCES SOME OF THE VARIABLES SINCE THE FISH ARE UNIFORM WITH RESPECT TO AGE AND DIET. THE DATA (FIGURE 5.9) DEMONSTRATES INCREASED MERCURY CONCENTRATIONS IN FISH FROM LAKES WITH LOWER pH IN THE HALIBURTON AREA OF ONTARIO. IT WAS FURTHER SHOWN THAT FOR LAKES WITH SIMILAR pH, THE MERCURY WAS HIGHER IN FISH FROM LAKES WITH A HIGHER RATIO OF DRAINAGE AREA/LAKE VOLUME. THIS RESULT IMPLIES THAT THE QUANTITY OF MERCURY FROM EITHER DIRECT ATMOSPHERIC DEPOSITION OR WATERSHED LEACHING IS INFLUENCING THE

MERCURY CONCENTRATIONS IN FISH. THE SURVEYS HAVE NOT BEEN CARRIED OUT LONG ENOUGH TO ESTABLISH ANY TRENDS WITH TIME.

IN 1980, THE SURVEY WAS EXTENDED TO INCLUDE ADULT BASS WHICH ARE AN IMPORTANT COMPONENT OF THE SPORT FISHERY. BASS FROM SIX OF THE NINE LAKES STUDIED HAD AVERAGE MERCURY CONCENTRATIONS ABOVE THE CANADIAN GUIDELINE FOR UNLIMITED HUMAN CONSUMPTION OF 500 NG/G. IN ONE LAKE, THE U.S. GUIDELINE OF 1000 NG/G WAS EXCEEDED.

THE FISHERIES WITHIN ONTARIO ARE THE BASIC RESOURCE FOR A SPORT FISHING INDUSTRY VALUED AT HUNDREDS OF MILLIONS OF DOLLARS PER YEAR. WHILE IN THE LONG-TERM, ACIDIFICATION OF LAKES POSES A THREAT TO THE INDUSTRY, IN THE SHORT-TERM, MERCURY IN FISH COULD LEAD TO FURTHER RESTRICTION ON HUMAN CONSUMPTION OF THE FISH WITH CONSEQUENTIAL ECONOMIC LOSS TO THE INDUSTRY.

#### 5.3.3.3 OTHER BIOLOGICAL EFFECTS

IN THE MUSKOKA-HALIBURTON AREA, DENSITIES OF SEVERAL SPECIES OF AMPHIBIANS DECREASE WITH INCREASING ACIDITY OF THEIR HABITAT. ACIDIC LAKES AND STREAMS SUPPORT A SMALLER BREEDING POPULATION OF SPRING PEEPERS (HYLA CRUCIFER) THAN MORE NEUTRAL HABITATS. DECIDUOUS WOODLAND PONDS ARE THE TYPICAL BREEDING HABITATS FOR AMBYSTOMA SALAMANDERS. HOWEVER, SUCH PONDS HAVE BEEN OBSERVED IN MUSKOKA-HALIBURTON TO BE VERY ACIDIC WITH pH'S AS LOW AS

4.3. THESE ACIDIC PONDS ARE NOW SELDOM USED AS BREEDING SITES AND THUS REPRESENT A LOSS OF HABITAT FOR THIS SPECIES. THE HATCHING SUCCESS OF ANY EGGS LAID IN THESE HABITATS IS LOW.<sup>13</sup>

ALTHOUGH RELATIVELY LITTLE WORK HAS BEEN DONE TO DATE ON THE EFFECTS OF ACIDIFICATION ON AQUATIC MACROINVERTEBRATES IN ONTARIO, NUMEROUS AQUATIC INSECTS ARE KNOWN TO BE AFFECTED BY ACIDIFICATION AND THEIR DISTRIBUTION HAS BEEN RELATED TO THE pH OF LAKES AND RIVERS (REVIEWED BY HARVEY ET AL<sup>26</sup>). FROM THESE STUDIES, IT APPEARS THAT MAYFLIES AND STONEFLIES ARE USUALLY SPARSELY DISTRIBUTED IN ACIDIC WATERS. MOLLUSCS (SNAILS AND CLAMS) AND MOULTING CRUSTACEANS ARE VERY SENSITIVE TO LOW pH WATERS.

THE ACIDIFICATION OF LAKES IN ONTARIO IS ACCCOMPANIED BY CHANGES IN THE OCCURRENCE AND ABUNDANCE OF ZOOPLANKTON AND REDUCTIONS IN THE DIVERSITY AND BIOMASS OF ZOOPLANKTON COMMUNITIES.<sup>26</sup> BOTH THESE TINY ANIMAL FORMS AND THE AQUATIC MACROINVERTEBRATES (INSECTS, CLAMS, SNAILS, ETC.) FORM IMPORTANT LINKS IN THE AQUATIC FOOD CHAIN CAPPED BY THE TOP PREDATORS, FISH.

THE DECLINE OF MACROPHYTE PLANT SPECIES AND THE CONCURRENT INVASION OF SPHAGNUM MOSS REPORTED IN ACIDIFIED LAKES IN SCANDINAVIA AND THE ADIRONDACKS (REVIEWED BY HARVEY ET AL 1981<sup>26</sup>) HAS NOT YET BEEN RECORDED IN ONTARIO LAKES. SPHAGNUM MOSS COVERAGE OF THE

NEARSHORE AREAS OF LAKES CREATES A HABITAT UNSUITABLE FOR USE AS FISH SPAWNING AND FEEDING GROUNDS.

THE ALGAE GROWING IN ACID STRESSED AND ACIDIC LAKES UNDERGO CHANGES IN SPECIES ABUNDANCE WHICH MAY BE DETRIMENTAL TO THE RECREATIONAL USE OF THE LAKES AND POSE A THREAT TO THE HABITAT OF SOME AQUATIC ORGANISMS. FOR EXAMPLE, LAKES WITH REDUCED pH SUPPORT A PROLIFERATION OF ALGAE ATTACHED TO THE BOTTOM (BENTHIC FILAMENTOUS ALGAE). THESE ALGAE CAN COAT (USUALLY GRAVEL) FISH SPAWNING BEDS MAKING SUCCESSFUL SPAWNING IMPOSSIBLE. SIGNIFICANT GROWTHS OF THESE ALGAE HAVE BEEN OBSERVED IN MUSKOKA-HALIBURTON LAKES SUCH AS PLASTIC, CHUB AND LEONARD.

ANOTHER OBSERVED CHANGE, DETRIMENTAL TO RECREATIONAL ACTIVITIES, IS THE APPEARANCE OF AN ALGA CALLED CHRYSOCHROMULINA BREVITURRITA NICH. WHICH IS CHARACTERIZED BY A SEVERE "ROTTEN CABBAGE" OR "GARBAGE DUMP" ODOUR WHICH HAS CAUSED LAKES TO BE UNSUITABLE FOR SWIMMING. OVER THE PAST THREE YEARS, THE ALGA HAS REACHED PROBLEM CONCENTRATIONS IN FOUR LAKES IN ONTARIO AND ONE IN NEW HAMPSHIRE. CROSSON LAKE HAS EXPERIENCED THE PROBLEM. DICKIE LAKE HAD AN EXTREME PROBLEM IN 1979 AND IT HAS HAD COTTAGEERS THERE FOR OVER 20 YEARS WITH NO PREVIOUS OBSERVATIONS OF THE ODOUR.<sup>32</sup> THE ODOUR IS SO BAD THAT RESIDENTS WOULD LIKELY HAVE REMEMBERED HAD IT EVER OCCURRED BEFORE.

THE ALGA HAS BEEN IDENTIFIED NOW AT VARIOUS POPULATION SIZES (DENSITIES) IN OVER 40 LAKES IN ONTARIO, MOST OF WHICH HAVE LOW pH.<sup>32</sup>

ALTHOUGH LITTLE INFORMATION HAS BEEN COLLECTED ON THE ROLE OF MICROORGANISMS IN ACID STRESSED SYSTEMS, STUDIES HAVE SHOWN THAT MICROBIAL DECOMPOSITION OF ORGANIC MATTER IS REDUCED AT LOW pH (REVIEWED BY HARVEY ET AL 1981).<sup>26</sup> IT IS BELIEVED THAT SUCH DISRUPTIONS WILL AFFECT THE NUTRIENT CYCLING AND HENCE OTHER TROPHIC LEVELS IN ACIDIFIED SURFACE WATERS.

#### 5.4 SUMMARY OF AQUATIC EFFECTS

THE CURRENT ACID LOADINGS TO PARTS OF THE PRECAMBRIAN ROCK AREAS OF ONTARIO, AND IN PARTICULAR, THE IMPORTANT RECREATIONAL AREAS OF MUSKOKE AND HALIBURTON, ARE CAUSING SOME LAKES AND RIVERS TO HAVE LOW pH VALUES FOR A FEW WEEKS DURING SPRING MELT AND FOR SEVERAL HOURS OR DAYS DURING HEAVY SUMMER AND AUTUMN RAINS. THESE LAKES ARE REGARDED AS ACID-STRESSED. ALUMINUM LEVELS IN SOME STUDY STREAMS ARE IN THE RANGE OF VALUES KNOWN TO BE LETHAL TO FISH FROM LABORATORY STUDIES.

THE ALKALINITY OF CLEAR LAKE IN HALIBURTON HAS DECLINED BY 60% OVER THE LAST 10 YEARS. THIS LAKE IS UNIQUE ONLY IN THAT LONG-TERM MEASUREMENTS ARE AVAILABLE. SIXTY TO

NINETY PER CENT OF THE LAKES SURVEYED IN THIS AREA OF ONTARIO ARE CLASSED AS EXTREMELY OR MODERATELY SENSITIVE TO ACIDIC INPUTS.

INTENSIVE STUDIES ON THE BIOLOGICAL EFFECTS OF OBSERVED WATER QUALITY CHANGES ARE BEING CARRIED OUT IN A SMALL NUMBER OF LAKES. FISH KILLS HAVE BEEN OBSERVED IN ONE LAKE. COMPLETE LOSS OF FISH POPULATIONS CONCOMITANT WITH LAKE ACIDIFICATION ARE KNOWN FOR SEVERAL LAKES, THE MECHANISM BEING RECRUITMENT FAILURE. THE LOSS OF OLDER FISH IN THE POPULATION IS OBSERVED IN ACID-STRESSED CROSSON LAKE.

MERCURY CONCENTRATIONS ARE ELEVATED IN FISH FROM LAKES WITH PH VALUES BELOW ABOUT 6.0. THERE IS REASON TO SUSPECT THAT INCREASED MAN-MADE ATMOSPHERIC EMISSIONS OF MERCURY FROM COAL BURNING, COUPLED WITH ACIDIFICATION OF PRECIPITATION AND SURFACE WATERS, WILL LEAD TO HIGHER MERCURY CONCENTRATIONS IN FISH AND TO MORE LAKES BEING AFFECTED.

ANY LOSS OR MODIFICATION OF THE QUALITY OF SPORT FISH IS A MAJOR CONCERN TO THE SPORT FISHING INDUSTRY VALUED AT HUNDREDS OF MILLIONS OF DOLLARS PER YEAR IN ONTARIO.

THE POTENTIAL FOR OTHER BIOLOGICAL EFFECTS HAS ALSO BEEN SHOWN AND IN MANY CASES DAMAGE HAS BEEN DOCUMENTED BY FIELD OBSERVATIONS. OBSERVED EFFECTS ON BIOTA IN ACIDIFIED SYSTEMS INCLUDE A DECLINE IN THE BREEDING

POPULATION OF CERTAIN AMPHIBIANS, REDUCED NUMBERS OF ZOOPLANKTON AND BENTHIC MACROINVERTEBRATES, CHANGES IN ALGAL COMMUNITIES, THE OCCURRENCE OF A FOUL SMELLING ALGA THAT RESTRICTS RECREATIONAL USE OF THE LAKE AND DECREASED MICROBIAL DECOMPOSITION RATES WITH POTENTIAL EFFECTS IN LAKE TROPHIC STATUS.

THE ACID STRESSED LAKES UNDER STUDY ARE SHOWING MANY INSTANCES OF BIOLOGICAL DAMAGE. IT IS HIGHLY LIKELY THAT SIMILAR DAMAGE IS OCCURRING IN THE THOUSANDS OF SIMILARLY ACID-STRESSED LAKES IN ONTARIO.



MAP 5.1

The Province of Ontario, shown relative to the Eastern part of the U.S. The shaded areas approximate environmentally sensitive terrain with lakes susceptible to precipitation acidity. The bulk of this terrain lies on the geological formation known as the Canadian Shield.

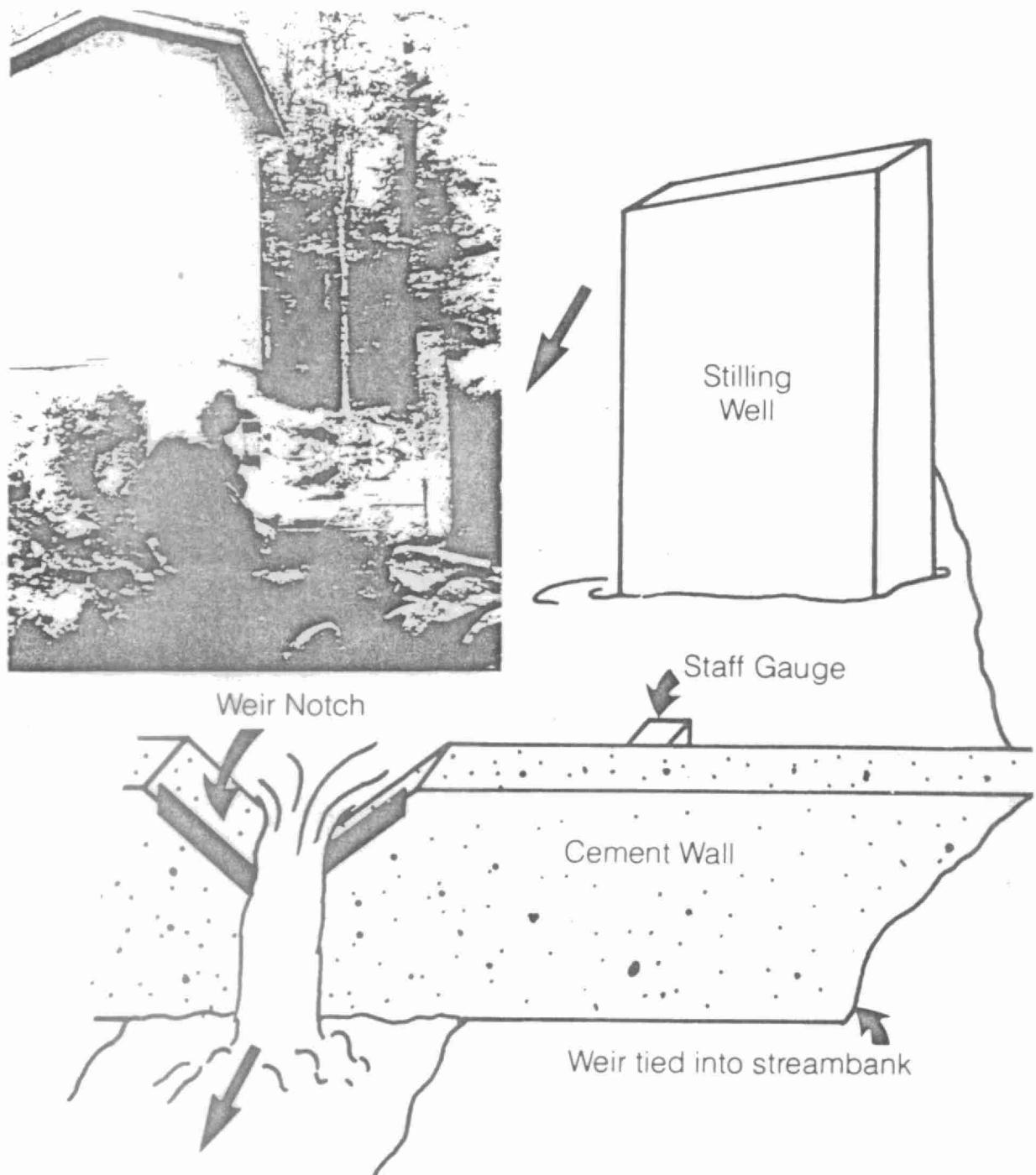


Figure 5.1 Actual and schematic examples of a weir designed to accurately record the flow of water in streams. Water samples are frequently collected for chemical analysis and concentrations and total amounts of chemical constituents passing through the weir are calculated.



Location of ten calibrated watersheds:

1. Experimental Lakes Area
2. Boundary Waters Canoe Area
3. Northern Highlands, WI
4. Sault Ste. Marie
5. Dorset
6. Sagamore Lake
7. Hubbard Brook
8. Laurentide
9. Kejimkujik Park
10. Coweeta

Figure 5.2 Regions of North America containing lakes that are sensitive to acidification by acid precipitation, based on bedrock geology, showing where calibrated watershed studies on sensitive areas are in progress.

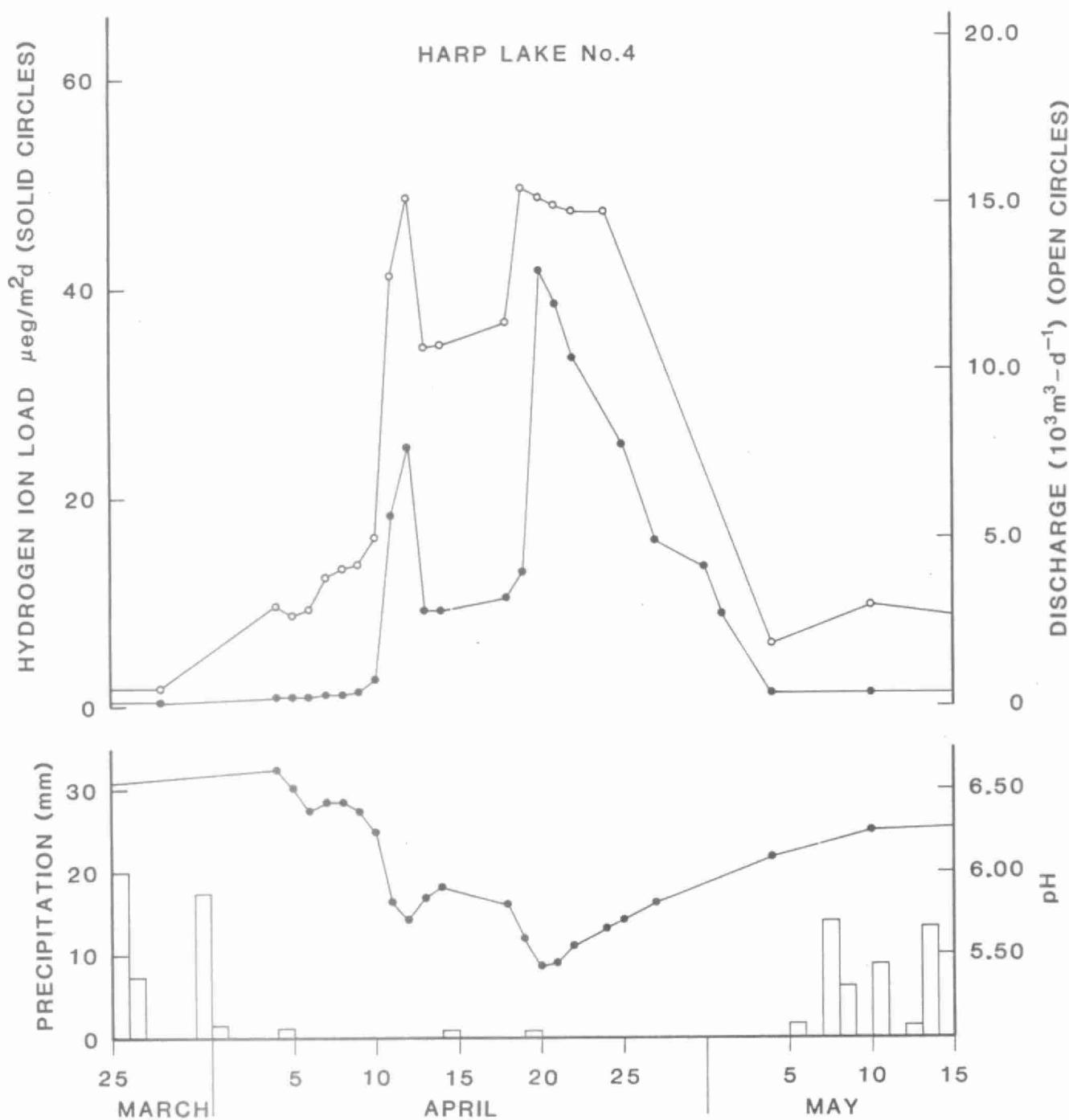


Figure 5.3 Spring pH Depression" of a Stream

Graph illustrating "spring pH depression" in one of the six inflowing streams to Harp Lake, a study lake in Muskoka.

As the spring runoff increases the amount of water, the acidic melted snow causes the stream pH to drop, producing severe chemical "shock" effects on aquatic life.

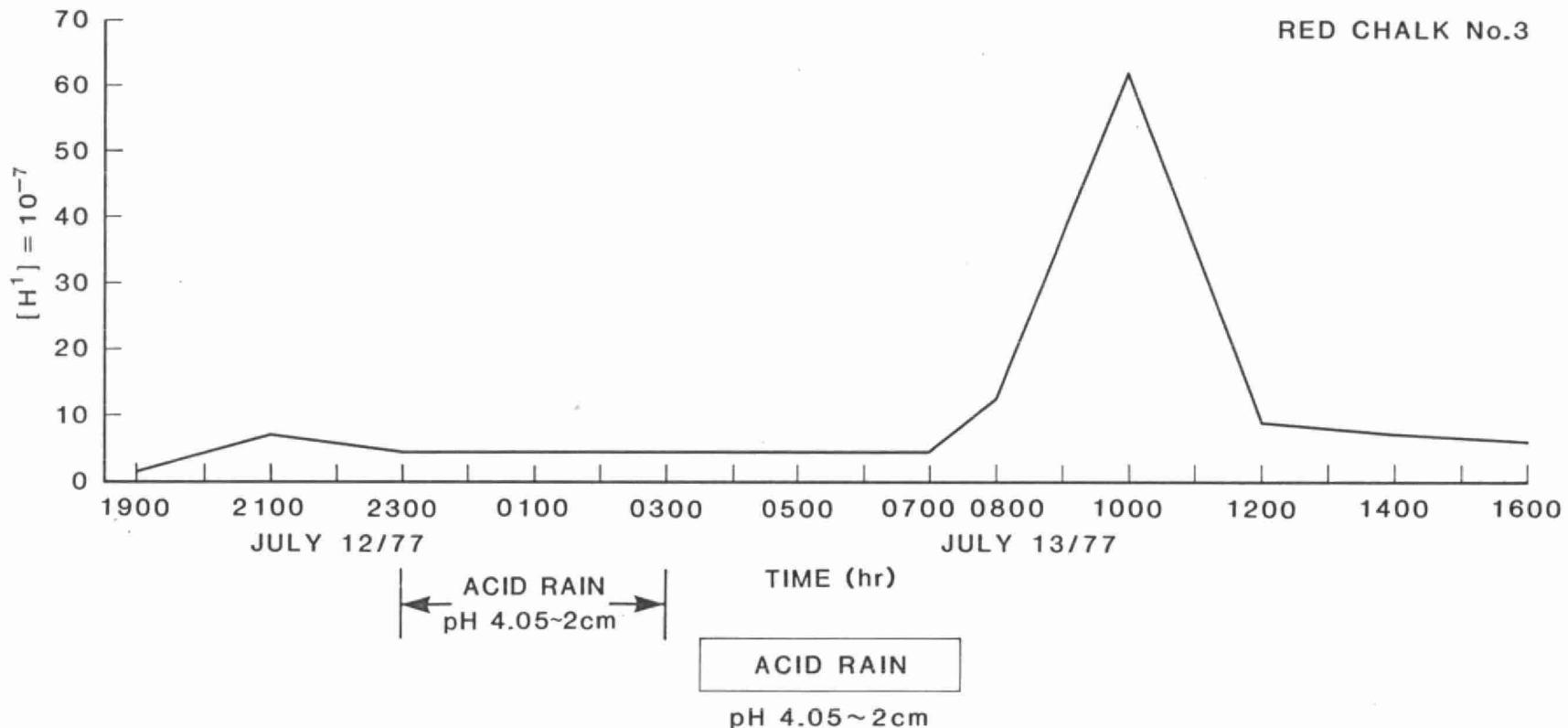
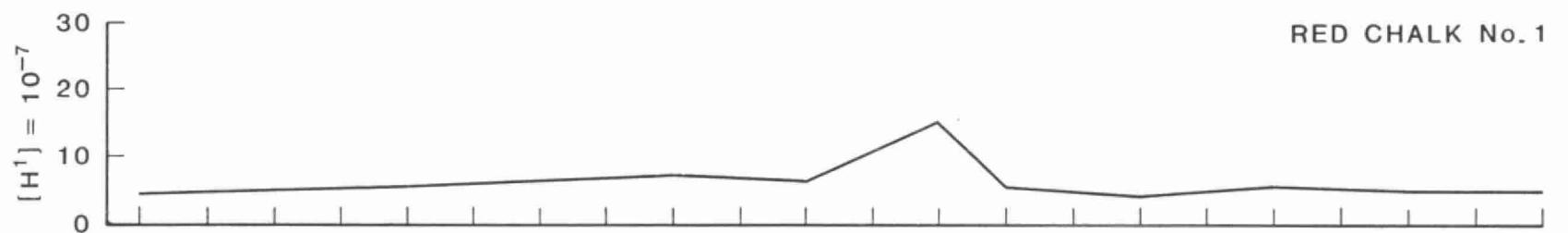


Figure 5.4 Hydrogen ion content of streams draining Red Chalk Lake watersheds No. 3 and No. 1 (Dorset, Ontario) showing effects of a 2cm rainfall (pH 4.06) between 11:00p.m. July 12, 1977 and 3:00a.m. July 13, 1977.

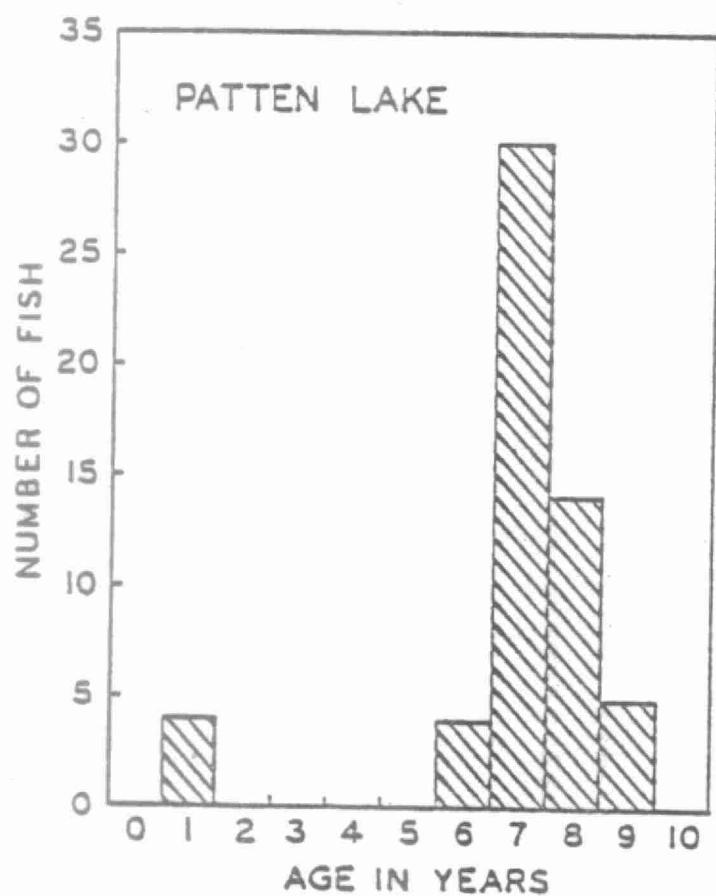


Figure 5.5 Age composition of yellow perch (*Perca flavescens*) captured in Patten Lake, Ontario, pH 4.1 (26).

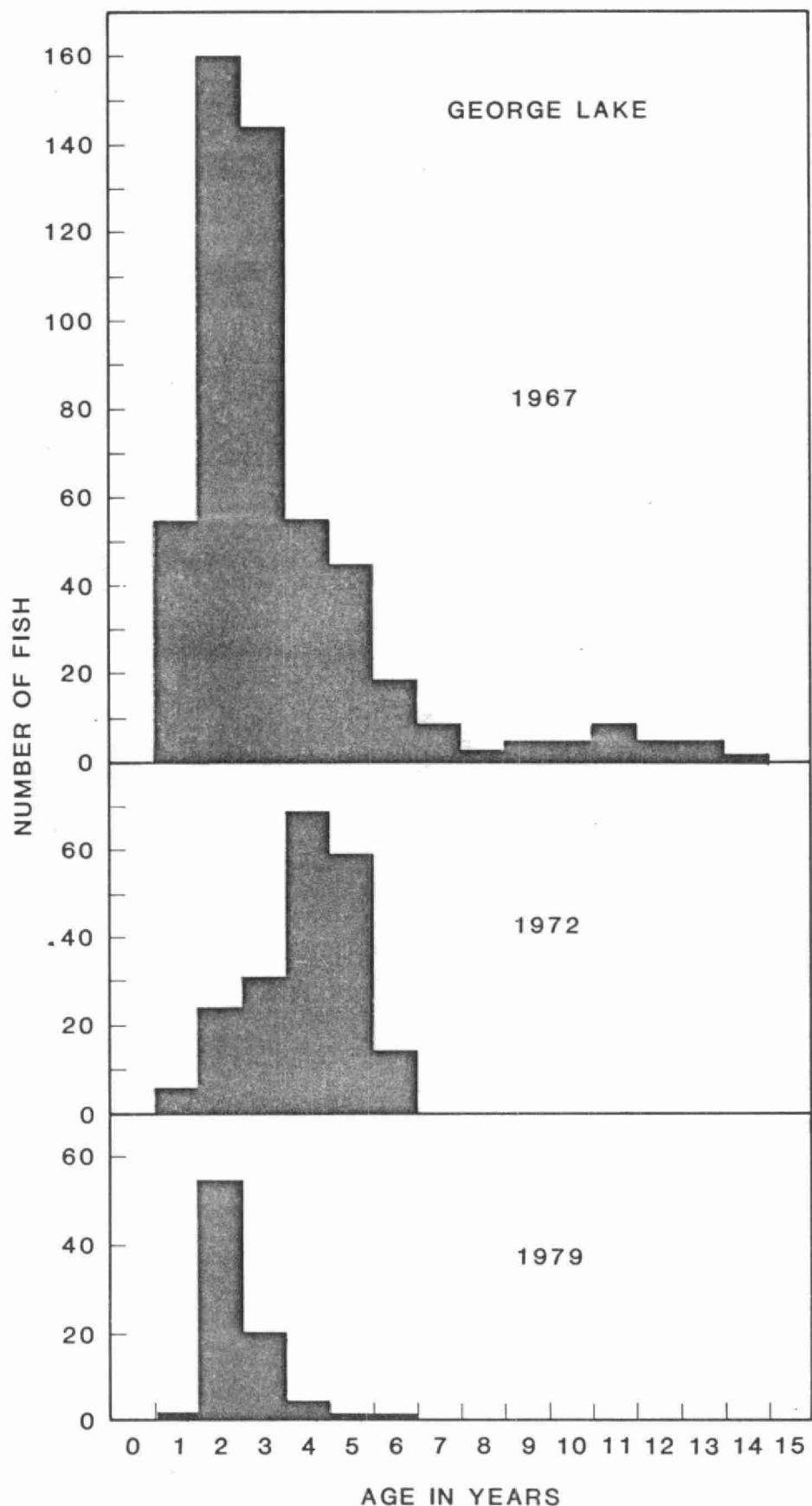


Figure 5.6 Changes in the age composition of the White Sucker in George Lake, Ontario (3,6,18).

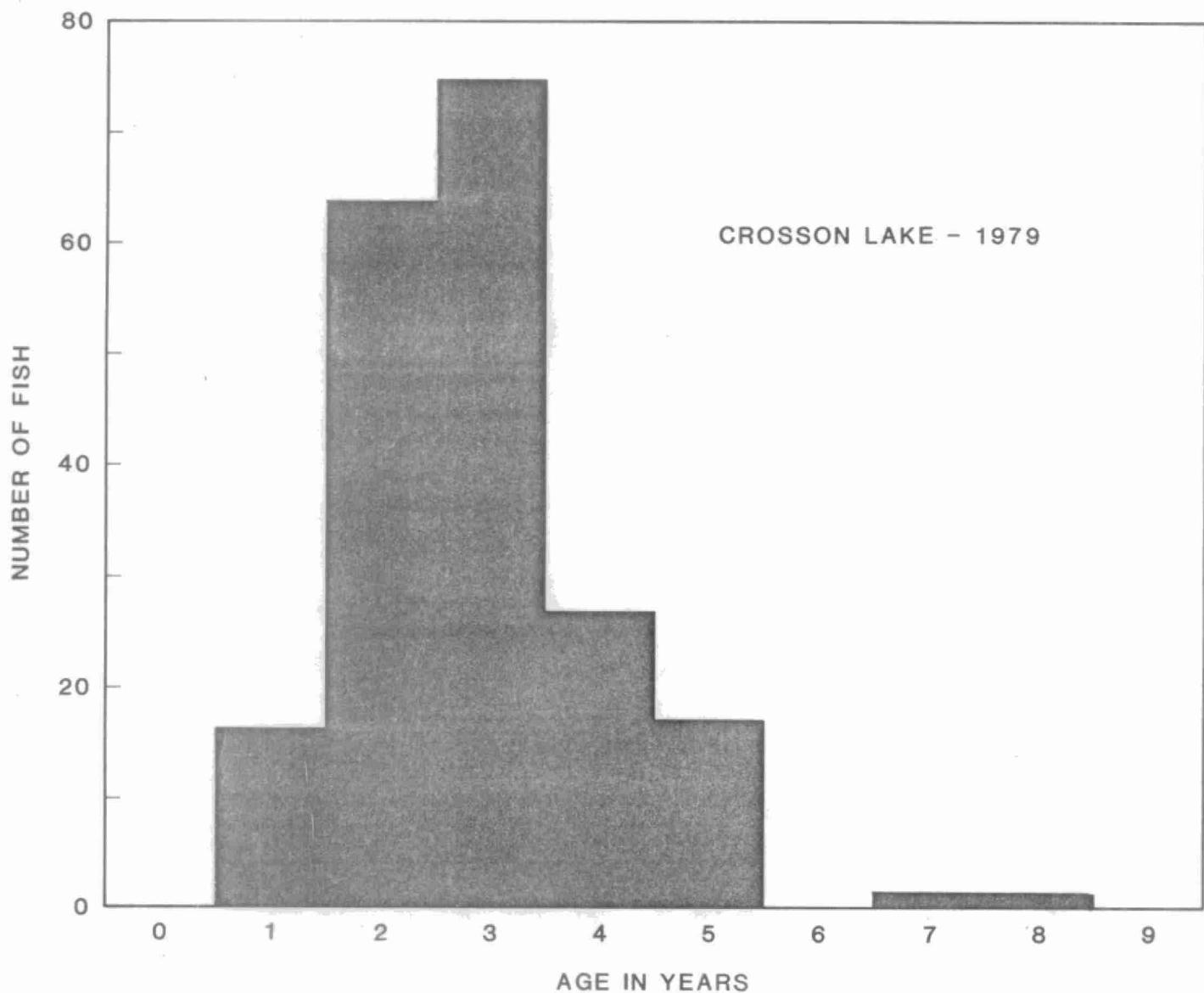


Figure 5. Age composition of the White Sucker in Crosson Lake (17).

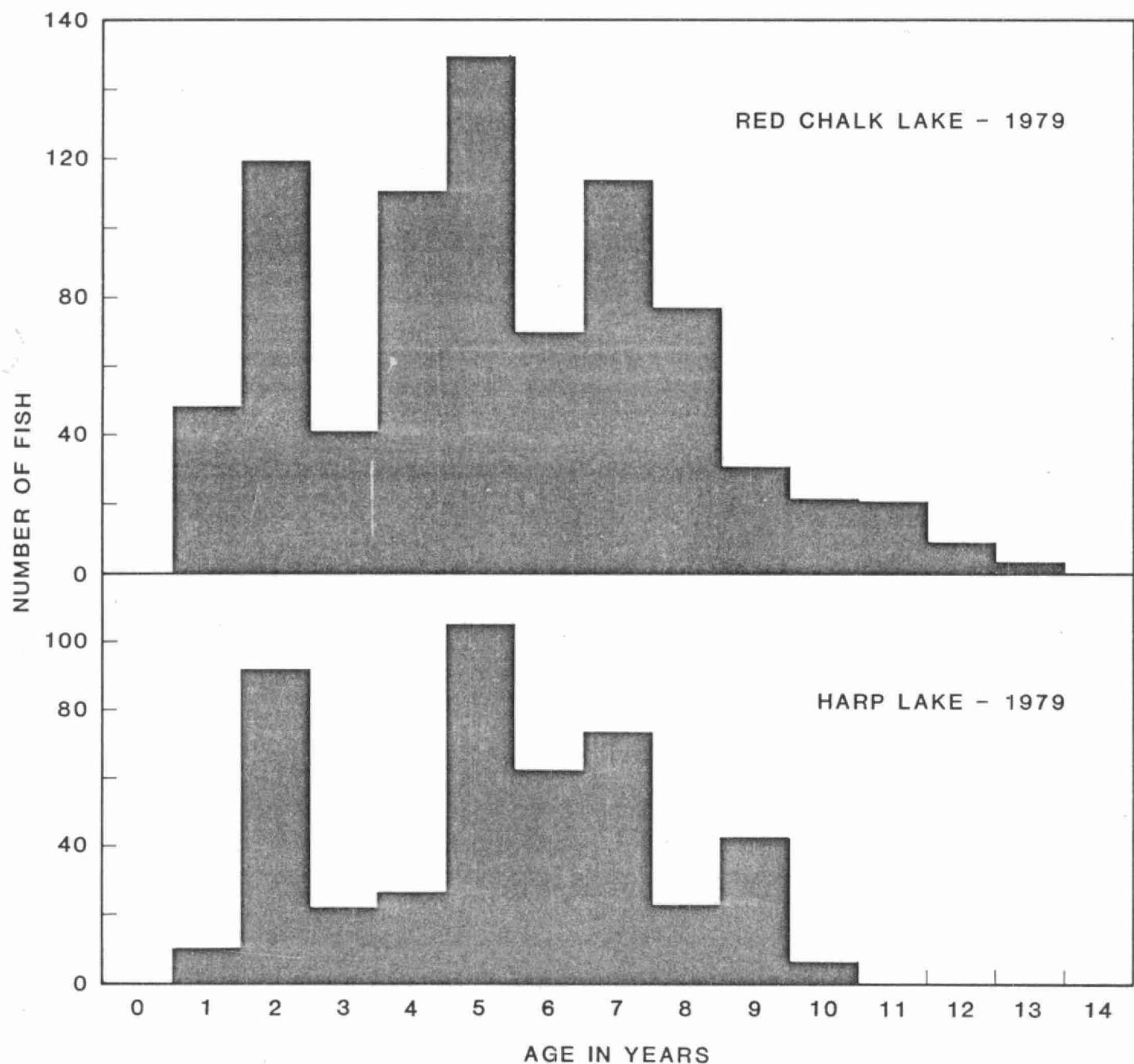
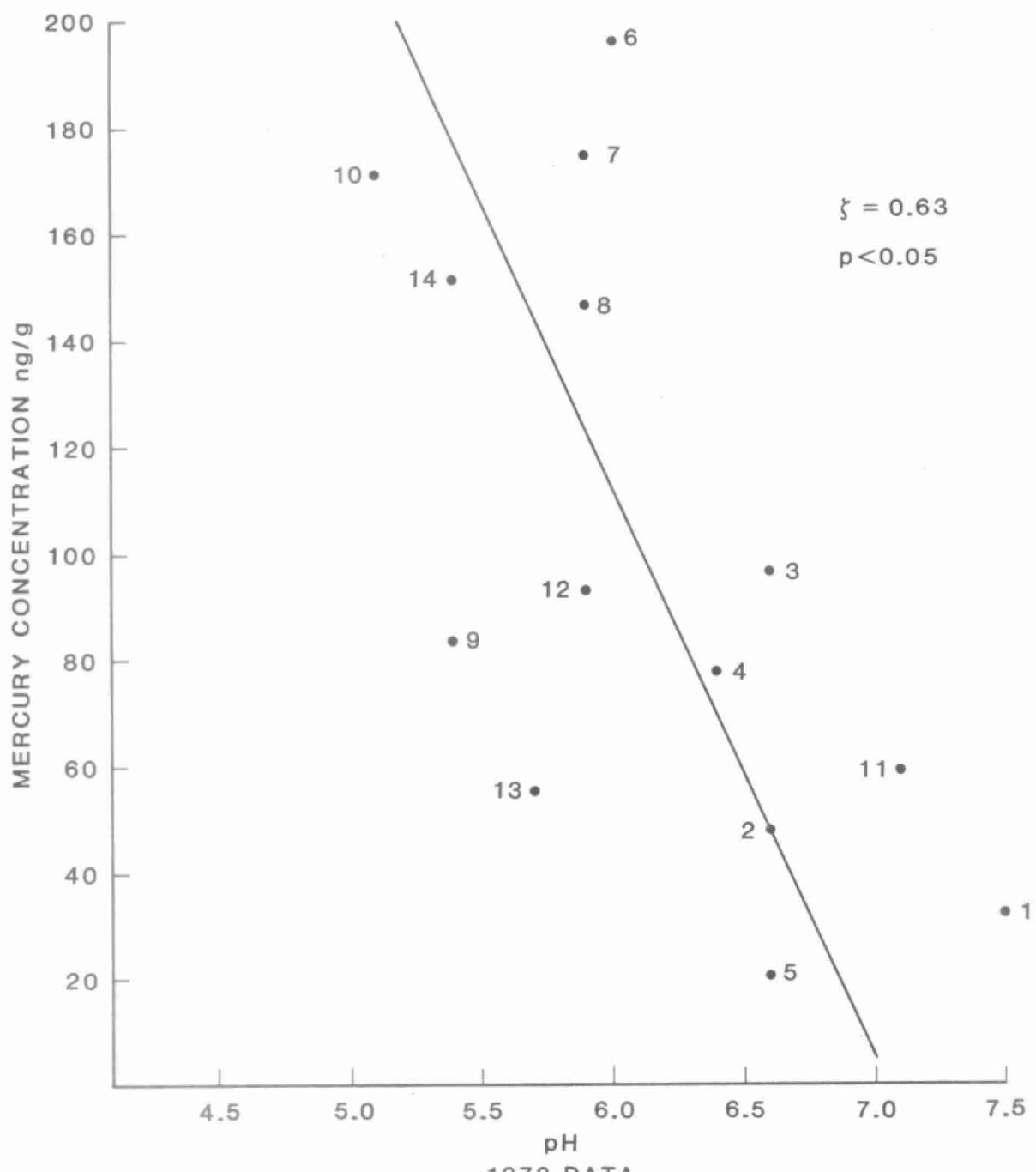


Figure 5.8 Age composition of White Sucker for Harp and Red Chalk Lake, 1979 (17).



1978 DATA			
LAKE #, NAME	TWP.	LAKE #, NAME	TWP.
1 DUCK LAKE	MINDEN	8 DICKIE LAKE	McLEAN
2 LITTLE CLEAR LAKE	SINCLAIR	9 LEONARD LAKE	MONCK
3 HARP LAKE	SINCLAIR	10 HENEY LAKE	McLEAN
4 BIGWIND LAKE	OAKLEY	11 CRANBERRY LAKE	GUILFORD
5 NELSON LAKE	BOWELL	12 HEALEY LAKE	McCAULEY
6 CHUB LAKE	RIDOUT	13 CLEAR LAKE	STANHOPE
7 CROSSON LAKE	OAKLEY	14 FAWN LAKE	McCAULEY

Figure 5.9 Mercury concentrations in yearling yellow perch and epilimnetic pH relationships (31).

TABLE 5.1

County or District	Percentage of Total Number of each Alkalinity Class					Total No. of Lakes Evaluated
	Extreme Sensitivity		Moderate Sensitivity	Low Sensitivity	Not Sensitive	
	Acidified (≤ 0 $\mu\text{eq L}^{-1}$ )	(> 0 to 39.9 $\mu\text{eq L}^{-1}$ )	(40 to 199 $\mu\text{eq L}^{-1}$ )	(200 to 499 $\mu\text{eq L}^{-1}$ )	(> 500 $\mu\text{eq L}^{-1}$ )	
Algoma Dist.	4	14	46	20	17	449
Bruce Co.	.	.	.	.	100	7
Cochrane Dist.	.	1	6	15	78	90
Durham Co.	.	.	.	.	100	1
Frontenac Co.	.	.	.	10	90	68
Grey Co.	.	.	.	.	100	3
Haliburton Co.	2	28	42	16	12	193
Hastings Co.	.	.	25	15	60	73
Huron Co.	.	.	.	.	100	1
Kenora Dist.	.	.	12	26	62	116
Lanark Co.	.	.	.	.	100	17
Leeds Co.	.	.	.	.	100	26
Lennox & Addington Co.	.	.	41	12	47	32
Manitoulin Dist.	49	30	3	3	15	33
Middlesex Co.	.	.	.	.	100	1
Muskoka Dist.	1	24	65	3	8	160
Nipissing Dist.	.	10	68	19	3	119
Northumberland Co.	.	.	.	.	100	1
Ontario Co.	.	.	.	.	100	5
Parry Sound Dist.	3	26	63	7	1	179
Peel Co.	.	.	.	.	100	1
Peterborough Co.	.	3	13	11	73	55
Prince Edward Co.	.	.	.	.	100	3
Rainy River Dist.	.	3	64	20	13	99
Renfrew Co.	1	3	20	26	50	105
Simcoe Co.	.	.	.	.	100	7
Stormont Co.	.	.	.	.	100	1
Sudbury Dist.	18	23	28	11	20	325
Thunder Bay Dist.	.	3	28	25	45	311
Timiskaming Dist.	14	14	23	23	27	109
Victoria Co.	.	.	.	56	44	27
York Co.	.	.	.	.	100	2
Provincial Total (Number of Lakes)	5 (118)	13 (331)	35 (929)	16 (430)	31 (811)	2619

TABLE 5.2

PH OF STREAMS IN MUSKOKA-HALIBURTON, ONTARIO, CANADA:  
STREAM pH IS GIVEN PRIOR TO SPRING RUNOFF (MID-MARCH 1978)  
AND AT MAXIMUM RUNOFF (MID-APRIL 1978)

Annual Average Alkalinity data from Scheider (Pers. Comm)

Waterhsed	Annual Average Alkalinity μeq/l	Stream Number	pH	
			Mid-March	Mid-April
Harp Lake	96	3	6.1	5.1
		3A	6.0	5.6
		5	5.9	4.8
		6	6.2	5.3
		6A	5.4	5.0
		Outflow	6.3	5.0
Dickie Lake	55	5	4.6	4.3
		6	4.6	4.4
		11	4.9	4.1
		Outflow	5.6	4.9
Chub Lake	61	1	5.8	5.1
		2	5.2	4.7
		Outflow	5.5	4.8
Red Chalk Lake	92	1	6.1	5.6
		2	4.5	4.3
		3	6.0	5.5
		4	6.2	5.5
		Outflow	6.1	5.9

Partial Table From: Jeffries et al., 1979

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## 6. SOCIO-ECONOMIC IMPLICATIONS

### 6.1 INTRODUCTION

THE DETROIT EDISON COMPANY HAS APPLIED TO THE MICHIGAN AIR POLLUTION CONTROL COMMISSION FOR AN EXTENSION TO A CONSENT ORDER WHICH WOULD PERMIT THE COMPANY TO CONTINUE TO BURN COAL WITH A SULPHUR CONTENT HIGHER THAN 1% AT ITS MONROE POWER PLANT BEYOND DECEMBER 31, 1984. UNDER THIS CONSENT ORDER THE COMPANY IS PRESENTLY PERMITTED TO BURN UP TO 2.3% SULPHUR COAL AND IS APPLYING TO BE ALLOWED TO BURN UP TO 2.1% SULPHUR COAL. UNDER PART 4 OF RULE 336.1401 OF THE MICHIGAN AIR POLLUTION CONTROL COMMISSION, DETROIT EDISON WOULD OTHERWISE BE REQUIRED TO BURN COAL WITH AN AVERAGE 1% SULPHUR CONTENT.

A COST-BENEFIT ANALYSIS WAS SUBMITTED AS PART OF THE APPLICATION DOCUMENTATION. THIS ANALYSIS PURPORTS TO SHOW THAT THE INCREMENTAL COSTS OF ACHIEVING SO<sub>2</sub> EMISSIONS THAT ARE EQUIVALENT TO THE 1% SULPHUR CONTENT ARE FAR IN EXCESS OF THE DOLLAR VALUE OF THE EXPECTED BENEFITS.<sup>7</sup>

IN THIS CHAPTER, THE METHODS USED IN THE COST-BENEFIT ANALYSIS ARE REVIEWED AND THE METHODS, RESULTS, AND CONCLUSIONS PRESENTED ARE THEN CRITIQUED. SUGGESTIONS ARE MADE AS TO HOW COST-BENEFIT ESTIMATING PROCEDURES COULD BE IMPROVED.

## 6.2 DETROIT EDISON - MONROE POWER PLANT CHARACTERISTICS

THE MONROE FACILITY IS A COAL-FIRED POWER PLANT LOCATED ON LAKE ERIE SOUTH OF DETROIT. THIS PLANT IS THE LARGEST OF EIGHT COAL-FIRED PLANTS OWNED AND OPERATED BY DETROIT EDISON. THE PLANT IS COMPRISED OF FOUR 750,000 KILOWATT (KW) STEAM TURBINE UNITS AND ONE 14,000 KW OIL-FIRED UNIT. THE TOTAL STATION CAPACITY IS, THEREFORE, 3,014,000 KW.<sup>8</sup>

AS OF JANUARY 1, 1979, DETROIT EDISON HAD A TOTAL GENERATING CAPACITY OF 9,261,150 KW WITH A "NET CAPABILITY" OF 8,591,000 KW. IN 1979, THE SYSTEM HAD SUMMER AND WINTER PEAKS OF 7,312,000 AND 6,157,000 KW RESPECTIVELY.<sup>8</sup> THE MONROE PLANT THUS ACCOUNTS FOR 35% OF THE NET GENERATING CAPABILITY OF THE COMPANY WHILE, IN 1978, THE PLANT PROVIDED 40% OF THE TOTAL POWER SOLD BY DETROIT EDISON. THE PLANT IS A BASE LOAD FACILITY, AND IN 1981, THE PLANT CAPACITY FACTOR WAS ABOUT 73%.<sup>3</sup>

IN 1979, THE PLANT PURCHASED ABOUT 6.9 MILLION TONS OF COAL, ABOUT 50% OF THE 13.994 MILLION TONS PURCHASED BY THE COMPANY DURING THAT YEAR.<sup>16</sup> THE PLANT WAS COMMISSIONED IN 1973 AND IS CURRENTLY EXPECTED TO BE RETIRED IN 2011.<sup>3</sup>

AS INDICATED IN TABLE 6.1, DETROIT EDISON SOLD 34,235 MILLION KILOWATT HOURS (MIL KWH) IN 1980, 7% FEWER KWH THAN IN 1979. DESPITE THIS ABSOLUTE DECLINE IN SALES,

TOTAL REVENUES INCREASED BY 6.5% TO \$1.8 BILLION IN 1980. MOREOVER, PROFITS FOR DETROIT EDISON INCREASED BY 7% BETWEEN 1979 AND 1980 TO \$188.6 MILLION, WHILE DIVIDEND PAYMENTS ROSE FROM \$157 MILLION TO \$179 MILLION.<sup>2</sup> OTHER FINANCIAL INDICATORS IMPLY THAT DETROIT EDISON IS IN A RELATIVELY STABLE FINANCIAL POSITION.<sup>2</sup>

STATE IMPLEMENTATION PLAN (SIP) OBJECTIVES INDICATE THE PERMITTED SO<sub>2</sub> EMISSIONS FOR EACH POWER PLANT; THEY MAY BE EXPRESSED IN TERMS OF THE ACCEPTABLE SULPHUR CONTENT OF THE COAL BURNED. THE SIP OBJECTIVES FOR EACH COAL-FIRED PLANT BELONGING TO DETROIT EDISON ARE SUMMARIZED IN TABLE 6.2 ALONG WITH CERTAIN OTHER PERTINENT DATA. IN 1979, THE SIP OBJECTIVES FOR DETROIT EDISON PLANTS RANGED FROM 1.0% TO 1.5% SULPHUR. EXCEPT FOR MONROE, THE ACTUAL % SULPHUR CONTENT OF COAL BURNED RANGED FROM 0.67% TO 0.90%. THE SIP OBJECTIVE FOR THE MONROE PLANT WAS 1.2% BUT THE PLANT ACTUALLY BURNED 2.37% COAL UNDER THE FIVE-YEAR CONSENT ORDER FROM THE MICHIGAN AIR POLLUTION CONTROL COMMISSION. CONSEQUENTLY, THE MONROE PLANT GENERATES APPROXIMATELY 265 THOUSAND TONNES OF SO<sub>2</sub> EACH YEAR OR ABOUT 75% OF THE TOTAL SO<sub>2</sub> PRODUCTION BY DETROIT EDISON. THIS MAKES MONROE THE FIFTH LARGEST SO<sub>2</sub> EMITTING POWER PLANT IN NORTH AMERICA. COAL ALONE ACCOUNTS FOR ABOUT 87% OF THE ENERGY OUTPUT OF THE COMPANY.

HOWEVER, ONLY 61.8% OF THE COAL BURNED BY DETROIT EDISON MEETS THE SIP OBJECTIVES FOR THE COMPANY AND ITS POWER PLANTS.<sup>16</sup>

AS PART OF ITS TWO VOLUME APPLICATION TO THE MICHIGAN AIR POLLUTION CONTROL COMMISSION, DETROIT EDISON PRESENTED A COST-BENEFIT ANALYSIS OF REDUCING THE EQUIVALENT SULPHUR CONTENT OF COAL BEING BURNED AT THE PLANT FROM 2.3 TO 1.0 PERCENT. BASED ON THIS ANALYSIS, DETROIT EDISON CONCLUDES THAT THE COSTS OF COMPLIANCE ARE UNREASONABLY DISPROPORTIONATE TO THE BENEFITS OBTAINED.

THE REQUIREMENT BY THE COMMISSION THAT COST-BENEFIT ANALYSIS BE APPLIED TO THESE ENVIRONMENTAL ISSUES AND QUESTIONS IS APPLAUDED. THE NEED TO ESTIMATE THE QUANTITATIVE BENEFITS OF ENVIRONMENTAL PROTECTION PROGRAMS AND POLICIES FORCES THOSE INVOLVED TO BETTER DOCUMENT THE CONSEQUENCES OF ABATEMENT PROGRAMS. HOWEVER, THERE ARE SEVERAL REASONS WHY BENEFITS MAY GENERALLY BE UNDERESTIMATED IN SUCH ANALYSES. FIRST, THERE IS SUBSTANTIAL UNCERTAINTY AS TO THE CHRONIC, LONG-TERM EFFECTS OF LOW LEVELS OF AIR POLLUTION AND ACIDIC DEPOSITION. SECOND, MONETARY OR DOLLAR VALUE ESTIMATES OF THE BENEFITS OF ABATEMENT PROGRAMS OFTEN UNDERSTATE THE SOCIAL SIGNIFICANCE OR RELATIVE IMPORTANCE OF THE BENEFICIAL BIOPHYSICAL EFFECTS OF ABATEMENT.

NEVERTHELESS, EFFORTS TO PREPARE AND CONSIDER COST-BENEFIT ANALYSES ENABLE ALL OF US TO DEVELOP TECHNIQUES, COLLECT RELEVANT DATA AND BECOME MORE FAMILIAR WITH THE CONCEPTS INVOLVED.

IN THE FOLLOWING SECTIONS, THE COMPUTATIONAL PROCEDURES AND THE ASSUMPTIONS USED IN THE COST-BENEFIT ANALYSIS ARE REVIEWED AND SOME QUESTIONS ARE RAISED.

### 6.3 COSTS

SECTION 3 OF VOLUME 2 OF THE APPLICATION PRESENTS AN ENGINEERING AND ECONOMIC EVALUATION OF VARIOUS PROGRAMS TO ACHIEVE THE SULPHUR IN FUEL COMPLIANCE REQUIREMENTS. THESE PROGRAMS CONSIST OF:

- BLENDING HIGH SULPHUR AND LOW SULPHUR FUELS,
- INSTALLATION OF FLUE GAS DESULPHURIZATION EQUIPMENT (SCRUBBERS),
- COAL CLEANING AND BENEFICIATION.

SEVEN SPECIFIC OPTIONS OR "ALTERNATIVES" WERE POSITED AND EVALUATED.<sup>7</sup>

1. THE BASE CASE - A BLEND OF 65% HIGH SULPHUR EASTERN (HSE) AND 35% LOW SULPHUR SOUTHERN (LSS) COALS TO MEET AN EQUIVALENT OF 2.3% SULPHUR IN FUEL.
2. ALTERNATIVE I - A BLEND OF 10% OF HSE AND 90% LSS, WITH NO MAJOR BOILER OR PRECIPITATOR MODIFICATIONS.
3. ALTERNATIVE II - A BLEND OF 20% HSE, 30% LSS, 50% LOW SULPHUR WESTERN (LSW), WITH MAJOR BOILER MODIFICATIONS AND NEW PRECIPITATORS ON ALL FOUR UNITS.

4. ALTERNATIVE III - A BLEND OF 20% HSE, 30% LSS, 50% LSW COALS, WITH MAJOR BOILER AND PRECIPITATOR MODIFICATIONS TO UNITS 1 AND 2 ONLY.

5. ALTERNATIVE IV - A BLEND OF 20% HSE, 30% LSS, 50% LSW COALS, WITH NO MAJOR PLANT MODIFICATIONS.

6. ALTERNATIVE V - A BLEND OF 10% HSE, 75% LSS, 15% LSW COALS, WITH NO MAJOR PLANT MODIFICATIONS.

7. ALTERNATIVE VI - UTILIZATION OF HIGH SULPHUR EASTERN COAL WITH THE ADDITION OF FLUE GAS DESULPHURIZATION (SCRUBBERS) ON ALL FOUR UNITS.

ALTERNATIVES II to VI PRESUMABLY WOULD REDUCE SO<sub>2</sub> EMISSIONS TO THE EQUIVALENT OF 1% SULPHUR IN THE FUEL; I.E., ABOUT 112 THOUSAND TONNES PER YEAR.

THE BASE CASE ASSUMES THAT THE MONROE PLANT CONTINUES TO OPERATE THROUGHOUT THE STUDY PERIOD (1985-2000) UNDER THE PRESENT CONSENT ORDER LIMIT OF AN EQUIVALENT OF 2.3% SULPHUR IN FUEL BY BURNING A BLEND OF 65% HIGH SULPHUR EASTERN COAL AND 35% LOW SULPHUR SOUTHERN COAL. PLANS TO CONSTRUCT A COAL BLENDING SYSTEM ARE UNDERWAY AND ARE ASSUMED TO BE COMPLETED BY 1985.

FOR EACH ALTERNATIVE, THE COMPANY HAS ESTIMATED THE "LEVELIZED ANNUAL COSTS" INCLUDING CAPITAL, OPERATING AND MAINTENANCE (O & M), INTEREST, FUEL AND REPLACEMENT ENERGY COSTS FOR THE YEARS 1985-2000.

THESE "LEVELIZED ANNUAL COSTS" ARE THEN COMPARED WITH THE "LEVELIZED ANNUAL COSTS" OF THE CURRENT "BASE CASE" WHERE THE COMPANY IS BURNING 2.3% SULPHUR COAL.

THESE COST ESTIMATES ARE PRESENTED IN TABLE 1 OF SECTION 4, VOLUME 2 OF THE COMPANY'S APPLICATION AND THE DIFFERENCES IN LEVELIZED ANNUAL COSTS BETWEEN THE BASE CASE AND EACH ALTERNATIVE ARE SUMMARIZED IN TABLE 6.3, ALONG WITH THE COMPANY'S ESTIMATES OF CAPITAL COSTS AND OTHER CONSEQUENCES OF EACH ALTERNATIVE.

ON THE BASIS OF THIS ANALYSIS, AND AS A RESULT OF BURNING TESTS IT HAS CARRIED OUT, THE COMPANY STATED THAT IT WOULD PREFER ALTERNATIVE I, A BLEND OF HIGH AND LOW SULPHUR EASTERN COALS. ALTHOUGH IT IS NOT THE LEAST-COST OPTION IN TERMS OF LONG-TERM FUEL COSTS, THIS OPTION APPEARS TO HAVE THE FOLLOWING ADVANTAGES FROM THE COMPANY'S POINT OF VIEW:

- A) CAPITAL COSTS ARE LOW;
- B) NO MODIFICATIONS TO EXISTING PARTICULATE CONTROLS ARE REQUIRED; AND
- C) THE BLEND HAS BEEN TESTED AND FOUND TO BE TECHNICALLY POSSIBLE WITH A LOW RISK OF TECHNICAL PROBLEMS AND DOWN TIME.

THIS ALTERNATIVE COULD BE IMPLEMENTED BY JANUARY 1, 1985.

ALL OF THE ALTERNATIVES INCLUDING, PRESUMABLY, FLUE GAS DESULPHURIZATION (FGD) OR SCRUBBERS (ALTERNATIVE VI) ARE DESIGNED TO ACHIEVE THE EQUIVALENT OF 1% SULPHUR COAL. AS NOTED, THIS WILL RESULT IN EMISSIONS OF ABOUT 112 THOUSAND TONNES OF SO<sub>2</sub> PER YEAR.

THE CAPITAL COSTS OF SCRUBBERS (ALTERNATIVE VI) FOR THE MONROE PLANT WERE CALCULATED BY THE COMPANY IN THE FOLLOWING MANNER. AN ESTIMATE OF INSTALLATION COSTS OF SCRUBBERS WAS MADE BY DETROIT EDISON IN 1980. THESE COSTS WERE COMPOUNDED BY 10% PER YEAR, TO ALLOW FOR INFLATION, FROM 1980 UNTIL THE SCRUBBING FACILITIES AND THE DISPOSAL SITE ARE COMPLETED AND IN SERVICE.

UNITS 1 AND 2 WOULD BE COMPLETED BY 1988, OR IN EIGHT YEARS, SO THAT CAPITAL COSTS FOR THESE UNITS AND THE DISPOSAL SITE ARE COMPOUNDED FOR EIGHT YEARS. UNITS 3 AND 4 WOULD BE FINISHED BY 1989 AND ARE COMPOUNDED FOR NINE YEARS. THUS, DETROIT EDISON ESTIMATES THAT THE CAPITAL COSTS AND INTEREST FOR UNITS 1 AND 2 WOULD TOTAL \$630.2 MILLION WHILE FACILITIES FOR UNITS 3 AND 4 WOULD COST \$634.3 MILLION, OR A TOTAL OF \$1,264.5 MILLION.<sup>15</sup>

STAFF IN THE MICHIGAN PUBLIC SERVICE COMMISSION (MPSC) REVIEWED THE COMPANY'S COST EVALUATION AND MADE THEIR OWN ESTIMATES.<sup>3</sup>

THE RESULTS OF THE MPSC CALCULATIONS GENERALLY CORROBORATE THOSE OF DETROIT EDISON AND INDICATE THAT THE COMPANY MAY HAVE UNDERESTIMATED SOME COSTS ON SOME OPTIONS. THE MPSC WORK CONCLUDES THAT DETROIT EDISON'S PREFERRED PROGRAM, ALTERNATIVE I, IS "LEAST-COST". THE COMMISSION ANALYSTS CALCULATE THAT THE COST INCREASES DUE TO THE VARIOUS ABATEMENT ALTERNATIVES COULD RESULT IN AN INCREASE IN HOME ELECTRICITY BILLS OF 4.3% TO 6.8% AND A RATE INCREASE FOR INDUSTRIAL CUSTOMERS BETWEEN 5.3% and 9.0%. COMMISSION STAFF "FEELS THAT THIS (THE RATE INCREASES) IS A SIGNIFICANT INCREASE AND SHOULD BE CAREFULLY BALANCED AGAINST THE BENEFITS EXPECTED FROM A SULPHUR DIOXIDE EMISSIONS REDUCTION PROGRAM".<sup>3</sup>

THE FINANCIAL BURDENS THAT ARE IMPOSED BY POLLUTION ABATEMENT COSTS CERTAINLY MUST BE CONSIDERED CAREFULLY AND WEIGHED, TO THE EXTENT POSSIBLE, AGAINST BENEFITS. HOWEVER, THERE ARE SEVERAL ASSUMPTIONS THAT HAVE BEEN MADE BY DETROIT EDISON AND THE COMMISSION THAT MAY GIVE RISE TO AN OVERESTIMATE OF THE EXTRA COSTS OF SOME OF THE ALTERNATIVES, ESPECIALLY ALTERNATIVE VI.

FLUE GAS DESULPHURIZATION (FGD) SYSTEMS HAVE THE POTENTIAL TO REDUCE EMISSIONS AT THE MONROE PLANT EVEN MORE. FOR THIS REASON, ESTIMATES OF FLUE GAS DESULPHURIZATION OR SCRUBBER COSTS ARE EXAMINED IN MORE DEPTH. THEREFORE, WE RESPECTFULLY SUGGEST THAT THE COSTING ASSUMPTIONS AND THE QUESTIONS WE HAVE ABOUT THEM

BE REVIEWED AND CONSIDERED BY THE COMPANY AND THE AIR POLLUTION CONTROL COMMISSION.

FIRST OF ALL, CAPITAL COSTS FOR THE FLUE GAS DESULPHURIZATION SYSTEM ARE ESTIMATED ON THE BASIS OF \$420 PER KW IN 1989. WE QUERY THE USE OF 1989 DOLLARS BECAUSE THE CONTRACTS FOR PROJECTS TO BE COMPLETED IN 1989 WILL BE LET IN 1984-85. WHILE VENDORS WILL TRY TO PROTECT THEMSELVES FROM COST INCREASES OVER THE CONSTRUCTION PERIOD, IT IS LIKELY THAT THE FINAL COSTS WILL BE CLOSER TO 1986-87 DOLLARS. MOREOVER, CONSTRUCTION COST INDICES HAVE LEVELLED OFF AND EVEN DECLINED IN THE U.S. SINCE OCTOBER 1981.<sup>5</sup> THE USE OF A 10% INFLATION RATE MAY WELL BE TOO HIGH FOR COST ESTIMATION OVER THE NEXT 5 TO 10 YEARS.

SECOND, THE CAPITAL COST PER KILOWATT FACTOR (\$420) WAS APPLIED TO THE ENTIRE 3,000,000 KW CAPACITY OF THE MONROE PLANT. TO ACHIEVE SO<sub>2</sub> EMISSION LEVELS THAT ARE EQUIVALENT TO THE 1% SULPHUR COAL, ONE WOULD NEED TO APPLY FLUE GAS DESULPHURIZATION ONLY TO 63% OF THE PLANT'S CAPACITY. APPLICATION OF FLUE GAS DESULPHURIZATION TO 75% OF THE TOTAL CAPACITY (I.E., TO THREE OUT OF THE FOUR GENERATING UNITS) WOULD PROVIDE BACK-UP REDUNDANCY IF REQUIRED AND THE POTENTIAL FOR REDUCTION OF SO<sub>2</sub> EMISSIONS TO BELOW THE EQUIVALENT OF 1% SULPHUR IN THE FUEL. IF THESE OBSERVATIONS ARE VALID, THE CAPITAL COSTS OF FLUE GAS DESULPHURIZATION MAY BE OVERSTATED.

LOWER CAPITAL COSTS WOULD OF COURSE LOWER THE FINANCING COSTS AS WELL.

EACH OF THE ALTERNATIVES WILL RESULT IN A "DERATING" OF THE POWER PLANT AND EXTRA COSTS TO REPLACE THIS LOST ENERGY PRODUCTION. THIS IS A RESULT OF THE ENERGY REQUIRED BY FLUE GAS DESULPHURIZATION DEVICES OR THE BURNING OF COAL THAT MAY BE INCOMPATIBLE WITH THE EXISTING BOILERS. THE COMPANY SUGGESTS THAT THE FLUE GAS DESULPHURIZATION SYSTEM WILL RESULT IN A DERATING IN EXCESS OF 20% OF THE PLANT CAPACITY. THE ENERGY REPLACEMENT COST IS ESTIMATED BY DETROIT EDISON TO AMOUNT TO \$236 MILLION PER YEAR FROM 1985-2000 WHILE THE MPSC ESTIMATES THE NET ENERGY REPLACEMENT COSTS TO TOTAL \$29.6 MILLION IN 1985 DOLLARS.

HOWEVER, ICF<sup>11</sup> AND PEDCO.<sup>13</sup> INDICATE THAT THE ENERGY PENALTY FOR FLUE GAS DESULPHURIZATION SYSTEMS WOULD RANGE ONLY FROM 3% TO 5%. USING 5% AS THE DERATE ASSUMPTION WOULD INDICATE EVEN LOWER REPLACEMENT ENERGY COST ESTIMATES THAN THOSE ESTIMATED BY THE MPSC.<sup>11, 13</sup>

ADDITIONALLY, THE ANNUAL COST OF HIGHER SULPHUR COAL THAT COULD BE USED IN CONJUNCTION WITH THE FLUE GAS DESULPHURIZATION SYSTEM WOULD APPEAR TO BE LOWER THAN THE LOW-SULPHUR COAL BLENDS THAT THE COMPANY IS NOW USING. THE COMPANY INCLUDES THESE COAL COST REDUCTIONS IN ITS OWN COST ESTIMATES BUT THE MPSC DOES NOT.

FINALLY AN OPTION WHICH ALSO EXISTS IS TO USE A LOWER COST TECHNOLOGY OF LOWER EFFICIENCY THAN WET SCRUBBING, E.G. DRY SCRUBBING, WHEREBY SOLIDS ARE INTRODUCED INTO THE EFFLUENT GAS STREAM TO ABSORB THE SULPHUR DIOXIDE.

WHILE THE CLAIM MAY BE MADE THAT SUCH TECHNOLOGY HAS NOT YET BEEN PROVEN, SUFFICIENT EXPERIENCE HAS BEEN OBTAINED OR WILL BE OBTAINED BY THE TIME SUCH A PROPOSAL HAS BEEN IMPLEMENTED TO REDUCE RISKS TO A MINIMUM.

REVISING THESE ASSUMPTIONS WOULD BRING THE ADDITIONAL COST OF A FLUE GAS DESULPHURIZATION SYSTEM DOWN TO ABOUT \$200 MILLION PER YEAR MAKING IT MORE FAVOURABLY COMPARABLE WITH ALTERNATIVE 1. ALTHOUGH CAPITAL COST REQUIREMENTS ARE STILL MUCH GREATER FOR FLUE GAS DESULPHURIZATION THAN FOR THE OTHER OPTIONS, THE LOWER LONG-TERM ANNUAL COST SAVINGS FROM USING HIGHER SULPHUR COAL COULD BE SUBSTANTIAL.

FINALLY, IF THE OPERATION OF THIS PLANT IS EXTENDED BEYOND 2011 AS IS EXPECTED, THE IMPACT OF CAPITAL COSTS OVER THE LIFE OF THE FACILITY WILL BE REDUCED PROPORTIONATELY. INDEED, CONTINUED OPERATION OF THE PLANT BEYOND 2011 COULD HAVE IMPORTANT IMPLICATIONS FOR THE BENEFITS OF AN EMISSION CONTROL PROGRAM WHICH ARE ADDRESSED BELOW.

#### 6.4 BENEFITS

THE BENEFITS OF BURNING 1% SULPHUR COAL RATHER THAN 2.3% SULPHUR COAL ARE THE REDUCTIONS IN ENVIRONMENTAL EFFECTS AND DAMAGES THAT RESULT FROM CHANGES IN EMISSIONS, AMBIENT AIR QUALITY AND ASSOCIATED ACIDIC DEPOSITION. PEOPLE MAY ALSO PERCEIVE AN INCREASE IN THEIR WELL-BEING FROM THE IMPROVED AIR QUALITY.

THE POSSIBLE DAMAGE EFFECTS FROM CHANGES IN AMBIENT AIR QUALITY INCLUDE HUMAN MORTALITY, MORBIDITY, VEGETATION EFFECTS AND DAMAGES TO MATERIALS. IN ADDITION, ACIDIC DEPOSITION CAN ADVERSELY AFFECT VEGETATION, MATERIALS AND AQUATIC SYSTEMS. THE VARIOUS DAMAGE-EFFECT CATEGORIES ARE SUMMARIZED IN TABLE 6.4.

IDEALLY, THE VALUE OF THE BENEFITS OF A POLLUTION CONTROL ACTION WOULD BE THE DIFFERENCE BETWEEN THE TOTAL MONETARY VALUE OF DAMAGES FROM THE NEW AMBIENT CONCENTRATION AND DEPOSITION LEVELS AND THE TOTAL MONETARY VALUE OF DAMAGES AT THE ORIGINAL AMBIENT CONCENTRATION AND DEPOSITION LEVELS.

THE VALUE OF THE BENEFITS OF SULPHUR DIOXIDE EMISSION REDUCTIONS HAS BEEN CALCULATED BY DETROIT EDISON USING METHODS THAT HAVE BEEN ACCEPTED BY THE MICHIGAN AIR POLLUTION CONTROL COMMISSION STAFF IN PRIOR SUBMISSIONS. THESE METHODS ARE SPELLED OUT IN COHEN<sup>6</sup> (OCTOBER 1977) AND CRITIQUED IN GREENFIELD AND PEYTON<sup>10</sup> (JANUARY 6, 1978).

COHEN (OCTOBER 1977) REVIEWS THE LITERATURE CONCERNING BIO-PHYSICAL ENVIRONMENTAL EFFECTS OF  $\text{SO}_2$  AND PARTICULATES AND THE METHODS THAT HAVE BEEN APPLIED TO DETERMINE MONETARY VALUES OF THESE BIO-PHYSICAL EFFECTS.<sup>6</sup> COHEN CITES MARGINAL DAMAGE COEFFICIENTS THAT HE USES TO ESTIMATE THE TOTAL CHANGE IN DAMAGE THAT RESULTS FROM CHANGES IN EMISSIONS. THE "MARGINAL ECONOMIC DAMAGE COEFFICIENT" IS THE DOLLAR VALUE OF A CHANGE IN BIO-PHYSICAL DAMAGE TO A PARTICULAR RECEPTOR CATEGORY, PER PERSON, PER YEAR, THAT RESULTS FROM A CHANGE IN  $1 \mu\text{g}$  PER CUBIC METER OF POLLUTANT. MARGINAL ECONOMIC DAMAGE COEFFICIENTS FOR  $\text{SO}_2$  AND PARTICULATES ARE LISTED IN TABLE 6.5.

IDEALLY, THESE COEFFICIENTS ARE DETERMINED BY ESTIMATING THE MONETARY VALUE OF THE CHANGE IN ANNUAL BIOPHYSICAL DAMAGES THAT ARE ASSOCIATED WITH A REDUCTION IN POLLUTANT CONCENTRATIONS. THIS FIGURE (\$/YEAR) IS THEN DIVIDED BY THE AVERAGE CHANGE IN AMBIENT CONCENTRATION ( $\mu\text{g}/\text{m}^3$ ) AND BY THE RELEVANT POPULATION (PER PERSON), TO ARRIVE AT \$ PER ( $\mu\text{g}/\text{m}^3$ ) PER PERSON PER YEAR.

IN PRACTICE, ESTIMATES OF THE MONETARY VALUE OF TOTAL BIOPHYSICAL DAMAGES OCCURRING AT CURRENT LEVELS OF AMBIENT CONCENTRATIONS ARE DIVIDED BY THE AVERAGE ANNUAL POLLUTANT CONCENTRATION AND BY THE RELEVANT POPULATION. THIS FIGURE IS THEN USED TO PREDICT THE MONETARY VALUE OF SPECIFIC CHANGES (REDUCTIONS OR INCREASES) IN POLLUTANT CONCENTRATIONS.

SOME CONTENTIOUS IMPLICATIONS OF THIS PROCEDURE INCLUDE:

- (a) THE INCREMENTAL VALUE OF DAMAGES IS CONSTANT AT ANY LEVEL OF POLLUTION.
- (b) DAMAGES CAN BE LINEARLY EXTRAPOLATED TO ZERO AMBIENT CONCENTRATIONS, EVEN AT AMBIENT CONCENTRATIONS BELOW AIR QUALITY STANDARDS.
- (c) THERE ARE NO THRESHOLDS.

COHEN FOCUSES ON HUMAN MORTALITY AND MORBIDITY AND MATERIALS DAMAGES. IT IS NOT CLEAR WHETHER ANY VEGETATION DAMAGES ARE INCLUDED IN THE "MATERIALS" COEFFICIENT. THIS DOES NOT APPEAR TO BE THE CASE, SINCE COHEN CONCLUDES THAT, WITH AMBIENT AIR QUALITY CONCENTRATIONS BELOW THE AMBIENT AIR QUALITY THRESHOLD LEVELS EMBODIED IN THE U.S. NATIONAL AIR QUALITY STANDARDS, NO COMMERCIAL CROP LOSSES WILL OCCUR.

GREENFIELD AND PEYTON ARGUE THAT "THERE IS NO APPARENT (SCIENTIFIC) BASIS FOR ASCRIBING HEALTH EFFECTS TO SO<sub>2</sub> CONCENTRATIONS BELOW THE CURRENT AMBIENT AIR STANDARDS" AND "THERE DOES NOT EXIST AN UNCONFOUNDED, VALIDATED DATA BASE TO SUPPORT ANY QUANTIFICATION OF PRESUMED OR SUGGESTED HEALTH EFFECTS AT CONCENTRATIONS PREDICTED ON CURRENT SO<sub>2</sub> STANDARDS".<sup>10</sup> MOREOVER, THEY ASSERT THAT "THERE DOES NOT EXIST ANY SUPPORTABLE (HEALTH) DAMAGE FUNCTION FOR SO<sub>2</sub> LEVELS BELOW CURRENT STANDARDS".

GREENFIELD AND PEYTON CITE THE MAJOR WORKS IN THIS FIELD ("CHESS", LAVE AND SESKIN, ETC.) ALONG WITH OTHER STUDIES TO BUTTRESS THEIR ARGUMENTS AND CONCLUSIONS.

CONSEQUENTLY, THEY ARGUE THAT THERE WOULD BE NO REDUCTIONS IN HEALTH EFFECTS RESULTING FROM THE AMBIENT AIR QUALITY CHANGES THAT WOULD OCCUR AS A CONSEQUENCE OF REDUCTIONS IN MONROE'S EMISSIONS BECAUSE CURRENT AMBIENT  $\text{SO}_2$  LEVELS ARE BELOW U.S. AIR QUALITY STANDARDS. THIS IS WHY DETROIT EDISON OMITS MORTALITY AND MORBIDITY DAMAGE EFFECTS FROM ITS COST-BENEFIT ANALYSIS.

WHILE GREENFIELD AND PEYTON AGREE THAT MATERIALS DAMAGE MAY BE OCCURRING AT CURRENT CONCENTRATIONS, THEY ARGUE THAT COHEN'S COEFFICIENT OVERSTATES THE VALUE OF THESE EFFECTS. COHEN<sup>6</sup> SUGGESTS A COEFFICIENT OF \$0.824/ $\mu\text{G}/\text{M}^3/\text{PERSON}/\text{YEAR}$  FOR MATERIALS DAMAGE (SEE TABLE 6.5) WHILE GREENFIELD AND PEYTON<sup>10</sup> CONCLUDE THAT "BETWEEN 20 AND 80  $\mu\text{G SO}_2/\text{M}^3$ , THE CHANGE IN ANNUAL PER CAPITA DAMAGE OF  $\text{SO}_2$  TO ALL MATERIAL IS ESTIMATED TO RANGE FROM \$0.34 AND \$0.50 (1977 DOLLARS) PER (CHANGE IN)  $\mu\text{G SO}_2/\text{M}^3$ ".<sup>6,10</sup> DETROIT EDISON THUS APPLIES A COEFFICIENT OF \$0.44/ $\mu\text{G SO}_2/\text{M}^3/\text{PERSON}/\text{YEAR}$  IN LOCATIONS WHERE MEAN ANNUAL  $\text{SO}_2$  CONCENTRATIONS ARE ABOVE 20  $\mu\text{G}/\text{M}^3$ . THE COMPANY ALSO MAKES ESTIMATES BASED ON THE COHEN'S COEFFICIENT (\$0.824/ $\mu\text{G}/\text{M}^3/\text{PERSON}/\text{YEAR}$ ) FOR COMPARATIVE PURPOSES.

THE VALUE OF BENEFIT ESTIMATES PRESENTED BY DETROIT EDISON AND THE PROCEDURES USED TO CALCULATE THEM ARE

SUMMARIZED IN TABLE 6.6. USING THE COEFFICIENT \$0.44/ $\mu\text{G}$   $\text{SO}_2$  / $\text{m}^3$ /PERSON/YEAR YIELDS AN ESTIMATE OF \$1.7 MILLION FOR MATERIALS DAMAGES IN 1977. THESE 1977 ESTIMATES ARE INCREASED BY 10% PER YEAR THROUGH 1989 (STEPS 3 AND 4, TABLE 6.6). USING A 10% DISCOUNT RATE, THE ANNUAL DAMAGE ESTIMATES FOR 1985-1989 ARE "PRESENT WORTHED". THE PRESENT WORTH VALUE USING \$0.44/ $\mu\text{G}$   $\text{SO}_2$  / $\text{m}^3$ /PERSON/YEAR AMOUNTS TO \$17 MILLION FOR THE FIVE YEARS; APPLICATION OF THE \$0.824 FACTOR YIELDS A PRESENT VALUE ESTIMATE OF \$30 MILLION.

THE COMPANY THEN USES THE COSTS FROM ALTERNATIVE I TO ESTIMATE EXTRA ANNUAL FUEL AND CAPITAL COSTS FOR EACH YEAR FROM 1985 THROUGH 1989. THESE VALUES ARE THEN "PRESENT WORTHED" USING A 10% DISCOUNT RATE. THE TOTAL "PRESENT WORTH" OF THE CAPITAL AND EXTRA OPERATING AND FUEL COSTS FOR THE ALTERNATIVE IS \$631 MILLION. THIS FIGURE IS 37 TIMES GREATER THAN \$17 MILLION AND 20 TIMES GREATER THAN THE \$30 MILLION BENEFIT ESTIMATE.

ON THE BASIS OF THIS ASSESSMENT, DETROIT EDISON ARGUES THAT COSTS ARE UNREASONABLY DISPROPORTIONATE TO THE BENEFITS.

THE FOREGOING ASSESSMENT OF BENEFITS REFERS ONLY TO THE MATERIALS DAMAGE EFFECTS OF AMBIENT AIR QUALITY. DETROIT EDISON SUBMITTED A REVIEW OF ACIDIC DEPOSITION ALONG WITH THEIR APPLICATION FOR THE CONSENT ORDER. THIS REPORT ONLY PROVIDES A REVIEW OF THE VARIOUS ASPECTS OF THE

PHENOMENON INCLUDING EFFECTS.<sup>7</sup> THE REPORT ALSO PROVIDES LISTINGS OF A NUMBER OF IMPORTANT REFERENCES AND RESEARCH PROGRAMS, AS WELL AS A COMPARISON OF EMISSIONS WITH ONTARIO HYDRO. NO ATTEMPT WAS MADE IN THIS OR ANY OF DETROIT EDISON'S OTHER DOCUMENTS TO ESTIMATE THE MAGNITUDE OF THE BIO-PHYSICAL EFFECTS OF ACIDIC PRECIPITATION OR THEIR ECONOMIC IMPLICATIONS.

#### 6.5 CRITIQUE OF BENEFIT ASSESSMENT

ARE THERE ANY REASONS TO THINK THAT BENEFITS ASSOCIATED WITH A REDUCTION IN SO<sub>2</sub> EMISSIONS AT THE MONROE PLANT WOULD BE GREATER THAN WHAT IS ESTIMATED BY DETROIT EDISON? IF SO, ARE THERE BETTER METHODS OF BENEFIT ESTIMATION THAT COULD BE EMPLOYED? THE FOLLOWING PARAGRAPHS ADDRESS THESE QUESTIONS.

THE ASSESSMENT PROVIDED BY DETROIT EDISON LIKELY UNDERSTATES BENEFITS FOR SEVERAL REASONS. FIRST, NO BENEFITS ASSOCIATED WITH ANY REDUCTIONS IN ACIDIC DEPOSITION ARE CONSIDERED. AS INDICATED IN TABLE 6.4, THESE BENEFITS WOULD BE THE REDUCTION IN DAMAGES CAUSED BY WET AND DRY DEPOSITION TO AQUATIC, TERRESTRIAL AND HUMAN SYSTEMS.

IN ADDITION, IT IS WELL ACCEPTED BY ECONOMISTS, GOVERNMENTS AND PRIVATE INDUSTRY THAT PEOPLE VALUE THE INTANGIBLE ATTRIBUTES OF THE ENVIRONMENT SUCH AS VISIBILITY, ODOURS, HISTORICAL AND ARCHEOLOGICAL ARTIFACTS, AND THE PRESERVATION OF CLEAN AIR AND WATER

FOR FUTURE GENERATIONS. WHILE THESE VALUES ARE NOT REVEALED IN PRIVATE MARKET TRANSACTIONS, QUESTIONNAIRE AND SURVEY PROCEDURES, CALLED CONTINGENCY VALUATION METHODS, HAVE BEEN DEVELOPED THAT YIELD RELIABLE AND ACCURATE ESTIMATIONS OF THE AMOUNTS PEOPLE ARE REALISTICALLY WILLING TO PAY TO GAIN A CLEANER ENVIRONMENT OR ALTERNATIVELY, WHAT THEY WOULD REQUIRE IN MONETARY COMPENSATION TO ENDURE A DECLINE IN ENVIRONMENTAL QUALITY. A CRITICAL REVIEW OF THE SURVEY METHODOLOGY CAN BE FOUND IN MYRA SCHIFF CONSULTANTS LTD.

1981 REPORT.<sup>12</sup>

THE VALUATIONS GENERATED BY THESE SURVEYS ARE COLLECTIVELY CALLED AMENITY VALUES AND THEY CAN BE ADDED TO THE ESTIMATES OF THE MONETARY VALUES OF REDUCED BIOPHYSICAL DAMAGES. THE AMENITY VALUES ASSOCIATED WITH REDUCING THE EMISSIONS FROM THE MONROE POWER PLANT ARE IGNORED ENTIRELY AND, BY IMPLICATION, ARE ASSUMED TO BE ZERO IN THE COST-BENEFIT ANALYSIS PROVIDED BY DETROIT EDISON.

CONTINGENCY VALUE SURVEYS HAVE SHOWN THAT MANY PEOPLE ARE WILLING TO PAY A POSITIVE AMOUNT OF MONEY TO ACHIEVE HIGHER AMBIENT AIR AND WATER QUALITY LEVELS. IT WOULD BE OF INTEREST TO LEARN HOW MUCH DETROIT EDISON'S CUSTOMERS MAY BE WILLING TO PAY IN RATE INCREASES TO ACHIEVE IMPROVEMENTS IN ENVIRONMENTAL QUALITY THAT WOULD RESULT FROM BURNING THE 1% SULPHUR COAL. A SURVEY OF THIS SORT COULD BE IMPLEMENTED AT A RELATIVELY LOW COST BY THE COMPANY.

LACKING ANY EXPLICIT INFORMATION ABOUT AMENITY VALUES, IT FALLS TO THE POLITICAL PROCESS TO JUDGE WHETHER THE AMENITY VALUES OF THE CLEANER AIR PLUS THE MONETARY VALUE OF ALL SPECIFIC BIOPHYSICAL IMPROVEMENTS (E.G. REDUCED MATERIALS DAMAGES) IS COMMENSURATE WITH THE COSTS OF ACHIEVING THE IMPROVEMENTS. IN ANY EVENT, AMENITY VALUES SHOULD NOT BE TOTALLY IGNORED AS THEY HAVE BEEN IN THE ANALYSIS TO DATE.

A THIRD FACTOR CONCERNS THE OMISSION OF MORTALITY AND MORBIDITY BENEFITS BECAUSE THE AMBIENT AIR QUALITY CONCENTRATIONS ALREADY ARE BELOW LEVELS WHICH ARE INTENDED TO PROTECT HUMAN HEALTH. HOWEVER, THE AMERICAN LUNG ASSOCIATION OF MICHIGAN AND DR. HOMER BOUSHEY (JUNE 9, 1981) HAVE ALREADY POINTED OUT THAT ASTHMATICS AND CERTAIN OTHER INDIVIDUALS IN THE POPULATION MAY SUFFER HEALTH EFFECTS AT RELATIVELY LOW LEVELS OF EXPOSURE.<sup>3</sup> WHILE THESE SENSITIVE INDIVIDUALS MAY REPRESENT A RELATIVELY SMALL POPULATION, ONE CANNOT SAY WITH CERTAINTY THAT THERE ARE NO HEALTH BENEFITS AT CONCENTRATIONS BELOW NATIONAL AMBIENT AIR QUALITY STANDARDS.

A FOURTH CONSIDERATION THAT COULD LEAD TO AN UNDERESTIMATION OF THE VALUE OF THE BENEFITS OF ABATEMENT ACTION IS THE FACT THAT THE COMPANY ONLY CITES BENEFITS FOR THE FIVE-YEAR PERIOD 1985-1989, THE PERIOD OF THE REQUESTED CONSENT ORDER. THESE BENEFITS, AND ANY OTHERS THAT SUBSEQUENTLY MAY BE DISCOVERED, WILL ACCRUE AS LONG

AS THE PLANT IS IN OPERATION. THIS MEANS THAT THE BENEFITS DURING THE YEARS 1985 to 2011 SHOULD BE INCLUDED. USING DETROIT EDISON'S FIGURES THE PRESENT VALUE OF THESE BENEFITS OVER THIS 26 YEAR PERIOD WOULD THEN BE \$86.5 MILLION WITH THE GREENFIELD & PEYTON COEFFICIENT AND \$162.5 MILLION USING THE COHEN FACTOR. THESE BENEFIT ESTIMATES OF COURSE WOULD BE LARGER IF THE PLANT WERE TO BE OPERATED LONGER THAN 2011. THESE ESTIMATES ALSO WOULD CHANGE SUBSTANTIALLY IF THE RATES OF INFLATION AND DISCOUNT WERE TO DIVERGE.

THE POINT TO BE MADE HERE IS THAT, BECAUSE OF UNCERTAINTY ABOUT THE VARIOUS FACTORS THAT ARE EMPLOYED IN THESE ESTIMATES, SINGLE-VALUED ESTIMATES LIKE THOSE THAT HAVE BEEN PRESENTED TELL US VERY LITTLE. RANGES OF ESTIMATES INDICATING WHICH FACTORS OR ASSUMPTIONS THAT CAN BE CHANGED PROVIDE BETTER COMPARATIVE INFORMATION. CONSEQUENTLY, IN ORDER TO MAKE A TRULY COMPREHENSIVE ASSESSMENT OF THE BENEFITS OF ABATEMENT, THE BIO-PHYSICAL EFFECTS OF REDUCTIONS IN AMBIENT AIR CONCENTRATIONS, ACIDIC DEPOSITION (WET AND DRY) AND THE RESULTING CHANGES IN AMENITIES SHOULD BE INCLUDED.

A MORE COMPREHENSIVE BENEFIT ESTIMATION PROCEDURE WOULD, THEREFORE, INCLUDE THE FOLLOWING STEPS:

1. IDENTIFICATION OF THE VARIOUS BIOPHYSICAL DAMAGE AND EFFECT CATEGORIES, INCLUDING AMENITY EFFECTS;

2. DETERMINATION OF RELEVANT BIO-PHYSICAL DOSE-RESPONSE RELATIONSHIPS;
3. ENUMERATION OF THE RELEVANT HUMAN, NATURAL AND MAN-MADE POPULATIONS THAT ARE AT RISK;
4. QUANTITATIVE ESTIMATION OF THE BIO-PHYSICAL EFFECTS OR CHANGES THAT OCCUR;
5. VALUATION, IN MONETARY UNITS, OF THESE BIO-PHYSICAL EFFECTS OR CHANGES; AND
6. QUANTITATIVE ESTIMATION OF THE AMENITY VALUES ASSOCIATED WITH THE CHANGES.

IT IS SUGGESTED THAT MORE EXPLICIT AND QUANTITATIVE INFORMATION ABOUT THE VARIOUS BIOPHYSICAL EFFECTS THAT ARE NOTED IN TABLE 6.4 WOULD BE USEFUL FOR THE MICHIGAN AIR POLLUTION CONTROL COMMISSION DELIBERATIONS. PRESENTING ONLY DOLLAR VALUE ESTIMATES OF THE BENEFITS TENDS TO HIDE INFORMATION ABOUT THE QUALITATIVE NATURE OF THE EFFECTS. IT IS RECOGNIZED THAT A DEARTH OF VERIFIED PHYSICAL DOSE-RESPONSE RELATIONSHIPS FOR MANY OF THE POLLUTANT-RECEPTOR CATEGORIES IS AN IMPORTANT IMPEDIMENT TO THESE TYPES OF ESTIMATES.

NEXT, A DISPLAY OF THE POPULATIONS AND RESOURCES AT RISK FROM THE POLLUTION DAMAGES WOULD FURTHER CLARIFY THE EXTENT OF ANY EFFECTS.

ONCE THE BIO-PHYSICAL AND AMENITY EFFECTS ARE IDENTIFIED AND ENUMERATED TO THE EXTENT POSSIBLE, THEN THE PROBLEM OF WEIGHTING THESE EFFECTS CAN BE ADDRESSED. MONETARY VALUES ARE ONE METHOD OF ASSIGNING WEIGHTS TO VARIOUS INCOMMENSURATE QUANTITIES. MARKET PRICES, WHERE AVAILABLE, PROVIDE WIDELY ACCEPTED MONETARY VALUATIONS THAT CAN BE USED IN COST-BENEFIT ANALYSES.

UNFORTUNATELY, MANY OF THE BIO-PHYSICAL AND AMENITY EFFECTS CAUSED BY POLLUTION DO NOT HAVE MARKET PRICES ASSOCIATED WITH THEM. THUS, EVEN WHERE THE EFFECT CAN BE MEASURED IN SPECIFIC UNITS (I.E. LIVES SAVED, REDUCED ILLNESSES, INCREASED SPORT FISHING AVAILABLE, ETC.). THERE IS, AS YET, NO STANDARDIZED, WIDELY ACCEPTED METHOD OF VALUATION THAT CAN BE APPLIED. EFFORTS ARE UNDERWAY TO DEVELOP AND TEST THESE METHODS.

WHILE THE COST-BENEFIT ANALYSIS PRESENTED BY DETROIT EDISON HAS PROVIDED ESTIMATES OF THE VALUE OF REDUCED MATERIALS DAMAGES, WE RESPECTFULLY SUGGEST THAT THESE ESTIMATES REPRESENT A MINIMUM VALUE OF THE BENEFITS OF SO<sub>2</sub> REDUCTIONS. WE SHALL CONTINUE TO SHARE WITH THE COMMISSION INFORMATION ON THE BIO-PHYSICAL BENEFITS OF SUCH ACTIONS AND WE URGE THE COMMISSION TO INITIATE WORK TO DETERMINE THE AMENITY VALUES OF ENVIRONMENTAL PROTECTION ACTIVITIES WHICH, EVEN DURING THESE TROUBLED ECONOMIC TIMES, CAN BE SUBSTANTIAL.

TABLE 6.1

DETROIT EDISON, SALES AND SELECTED STATISTICS

	<u>1980</u>	<u>1979</u>	<u>1974</u>
1. Total Elect. Sales (mill Kwh)	34,235	36,891	33,412
2. Total Elect. Sales (\$000's)	\$1,776,364	\$1,667,679	\$881,301
3. Electricity Revenues as a % of Gross Revenues	98.0	98.2	98.1
4. Total Operating Costs (\$000's)	\$1,498,128	\$1,424,990	\$731,025
5. Net Income or Profits (\$000's)	\$188,566	\$176,029	\$89,200
6. Total Coal Purchased (000 tons)	N/A	13,994.0	N/A
Average Electricity Rates (¢/Kwh)			(1975)
- Residential	5.62	5.11	3.67
- Commercial	6.10	5.53	3.89
- Industrial	4.25	3.60	2.42

Source: Moody's Public Utility Manual, 1980, Vols. 1 & 2.

TABLE 6.2

S.I.P. OBJECTIVES AND SO<sub>2</sub> EMISSIONS FROM COAL-FIRED  
POWER-PLANTS OWNED BY THE DETROIT EDISON COMPANY

Plant	Location	Generation Capacity	Fuel Burned	Capacity Factor	% Sulphur in Coal		Annual SO <sub>2</sub> Emissions (000 tonnes)	Amount of Coal Burned in 1979 (000 tons)
					S.I.P. Objectives	1979 Actual Average		
		1978 (MW)		(%)				
St. Clair	Bell River	1,754	coal, oil	51.4	1.49	0.67	39.7	2,899.0
River Rouge	River Rouge	787	coal, oil	50.1	1.5	0.79	16.5	1,434.0
Conners Creek	Detroit	604	coal, oil, gas	20.2	1.26	0.79	6.4	414.0
Trenton Channel	Trenton	720	coal, oil	65.1	1.0	0.92	23.2	1,648.0
Marysville	Marysville	228	coal, gas	42.8	1.5	0.80	4.5	316.0
Harbor Beach	Harbor Beach	114	coal, oil					251.0
Pennsalt	Riverview	14	coal, oil					120.0
Monroe	Monroe	3,014	coal, oil	56.1	1.2	2.37	264.8	6,912.0
Total		7,235					355.1	13,994.0

Source: Electrical World, Directory of Electric Utilities, 1979-1980, 88th Edition.  
New York: McGraw-Hill Publishing Co., 1979.

U.S. Department of Energy, Energy Information Administration,  
Cost and Quality of Fuels for Electric Utility Plants. - 1979, June 1980.

TABLE 6.3

SUMMARY OF CAPITAL COSTS AND OTHER CONSEQUENCES OF SO<sub>2</sub>  
ABATEMENT OPTIONS AT THE MONROE POWER PLANT

Alternative	Description of Alternative	Capital Costs (\$ million)	Difference From Annual Base Case Costs (\$ million)	Unit Availability	Average Unit Derate	Risk of Technical Problems	Other
Base Case	65% HSE 35% LSS Existing Precip.	0.0		High	0	-	
I	10% HSE 90% LSS Existing Precip.	\$15.5	308.3	High	170 MW	Low	Flue Gas Conditioning Equipment on Units 3 & 4.
II	20% HSE 30% LSS 50% LSW 4 New Precips.	\$744.5	276.6	High	145 MW	High	Flue Gas Conditioning Equip., four new precipitators, extensive modifications.
III	20% HSE 30% LSS 50% LSW 2 New Precips.	\$433.5	274.1	1 & 2 high 3 & 4 lower	1 & 2 150 MW 3 & 4 230 MW	High	
IV	20% HSE 30% LSS 50% LSW Existing Precips.	\$15.5	372.0	Lower	250 MW	Medium	Gas Conditioning equipment on units 3 and 4.

. . . continued/

TABLE 6.3 (cont'd)

Alternative	Description of Alternative	Capital Costs (\$ million)	Difference From Annual Base Case Costs (\$ million)	Unit Availability	Average Unit Derate	Risk of Technical Problems	Other
V	10% HSE 75% LSS 15% LSW Existing Precips.	\$15.5	\$396.8	Lower	210 MW	Low	
VI	100% HSE Scrubber Existing Precips.	\$1,264.5	\$493.8	Lower	240 MW	High	Limestone slurry system plus costs of disposal.

N.B. HSE - High Sulphur Eastern (or Southern) coal.

LSS - Low Sulphur Southern (or Eastern) coal.

LSW - Low Sulphur Western coal.

Source: Detroit Edison, Application of the Detroit Edison Company for an extension of the compliance date for Sulphur Dioxide Emissions at the Monroe power plant, May 1981, Vol. 2, pp. 3-3 to 3-8.

TABLE 6.4

POLLUTANTS FROM A POWER PLANT AND THE VARIOUS RECEPTOR CATEGORIES WHICH CAN BE AFFECTED

<u>Biophysical Receptor Effect/Category</u>	<u>Pollutant Type</u>			<u>Acidic Deposition</u>	
	<u>SO<sub>2</sub></u>	<u>NO<sub>x</sub></u>	<u>Particulates</u>	<u>Wet</u>	<u>Dry</u>
<b>Human Health</b>					
Mortality	Y	Y	Y	-	-
Morbidity	Y	Y	Y	-	-
<b>Vegetation</b>					
Agricultural Crops	Y	Y	Y	-	-
Forests	Y	Y	Y	-	-
Animals and Livestock	Y	Y	Y	-	-
Materials and Structures	Y	?	Y	Y	Y
Water Quality and Aquatic Systems	Y	?	?	Y	Y
Human Perceptions and Aesthetics	Y	-	Y	-	-

Code: Y = effect has been observed.

- = no known effect.

? = no information available.

TABLE 6.5

DAMAGE COEFFICIENTS FOR SO<sub>2</sub> AND PARTICULATES

(\$/ug/m<sup>3</sup>/person/year)

Receptor Category	<u>Particulates</u>	<u>Sulphur Dioxide</u>	
	Literature Survey	Cohen, Fishelson and Gardner (1974)	
<u>Human Health</u>			
Mortality	\$0.294	\$0.394	\$0.294
Morbidity	\$0.721	\$0.100	\$0.721
Materials	<u>\$2.320</u>	<u>\$0.428</u>	<u>\$0.824</u>
Total	<u>\$3.330</u>	<u>\$0.922</u>	<u>\$1.840</u>

Source: Cohen (1977, pp. 14 and 21)

TABLE 6.6

DETROIT EDISON CALCULATION OF MONETARY VALUE OF THE  
BENEFITS OF SO<sub>2</sub> EMISSION REDUCTIONS AT THE MONROE POWER PLANT

Step 1. Calculation of weighted SO<sub>2</sub> reductions.

Step 2. Calculation of the value of annual damages in 1977 \$ (multiply Pop x SO<sub>2</sub> x Column one or column 2 factor.)

County (1990 Est.)	<u>Population</u>	X	<u>SO<sub>2</sub> Reduction</u>	=	<u>Pop. X SO<sub>2</sub></u>	X	<u>Column One</u>	<u>Column Two</u>
							<u>Greenfield &amp; Peyton (Jan. 1978)</u>	<u>Cohen (Nov. 1977)</u>
							<u>(\$0.44/ug SO<sub>2</sub>/M<sup>3</sup> person/year)</u>	<u>(\$0.824/ug SO<sub>2</sub>/M<sup>3</sup>/person/year)</u>
Monroe	157,479		0.98		154,329			
Lenawee	95,600		0.68		65,008			
Washtenaw	346,159		0.68		235,388			
Wayne	2,257,133		1.01		2,279,388			
Lucas, Ohio	505,831		0.98		495,714			
Wood, Ohio	133,098		0.75		99,824			
Ottawa, Ohio	50,975		0.87		43,565			
Essex	290,000		1.79		519,100			
					<u>3,892,632</u>		<u>\$1.7 million</u> <u>\$1,712,758</u> <u>(1977)</u>	<u>\$3.2 million</u> <u>\$3,207,528</u> <u>(1977)</u>

TABLE 6.6 (cont'd)

		<u>Column One</u>	<u>Column Two</u>
		<u>Greenfield and Peyton</u>	<u>Cohen</u>
Step 3	Escalating 1977 \$ to 1985 \$ at 10% per year:	\$3.67 million (1985)	\$6.88 million (1985)
Step 4	Estimation of current value of benefits between 1985 and 1989 (5 year duration of Consent Order) by escalating 1985 value by 10% per year:	1985 \$3.67 million 1986 \$4.04 1987 \$4.44 1988 \$4.88 1989 \$5.37	\$6.88 million \$7.57 \$8.32 \$9.16 \$10.07
Step 5	Computation of "present worth" (present value) using 10% 10% discount rate	1985 \$3.33 million 1986 \$3.33 1987 \$3.33 1988 \$3.33 1989 \$3.33	\$6.25 million \$6.25 \$6.25 \$6.25 \$6.25
Step 6	The cumulative present worth of the benefits, 1985-1989:	\$16.65 million	\$31.25 million

Source: DETROIT EDISON, 1981. Application of the Detroit Edison Company for an Extension of the Compliance Date for Sulphur Dioxide Emissions at the Monroe Power Plant. May 1981, Volume 1 and 2.

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7. CONCLUDING REMARKS

ONTARIO'S POSITION IS THAT EMISSIONS OF OXIDES OF SULPHUR FROM THE DETROIT EDISON MONROE POWER PLANT CONTRIBUTE TO SERIOUS DEGRADATION OF ONTARIO'S ENVIRONMENT. TABLE 7.1 SHOWS THE TREND IN SO<sub>2</sub> EMISSIONS IN ONTARIO FOR THE PERIOD 1970 TO 1990, A DROP IN EMISSIONS OF MORE THAN 50%. THE EFFECTS OF THIS WILL BE NEGATED SHOULD THE UNITED STATES ALLOW ITS SOURCES TO INCREASE THEIR EMISSIONS. WHILE FURTHER RESEARCH WILL BE HELPFUL, THERE IS NOW CLEAR EVIDENCE OF SIGNIFICANT TRANSPORT OF DAMAGING POLLUTION FROM THE MIDWESTERN STATES TO RECEPTOR AREAS IN EASTERN CANADA, NORTHEASTERN AND MID-WESTERN UNITED STATES. TO ALLEVIATE THIS, THE PROVINCE OF ONTARIO URGES THE GOVERNMENTS OF THESE STATES AND THE UNITED STATES FEDERAL ADMINISTRATION TO ACT NOW AND ENFORCE THE STATE OF MICHIGAN'S "1% OR EQUIVALENT SULPHUR IN FUEL" RULE.

IT IS WORTH NOTING THAT THE RECENT NATIONAL ACADEMY OF SCIENCE REPORT ENTITLED "ATMOSPHERE - BIOSPHERE INTERACTIONS; TOWARDS A BETTER UNDERSTANDING OF THE ECOLOGICAL CONSEQUENCES OF FOSSIL - FUEL COMBUSTION", VERY STRONGLY SUPPORTS ONTARIO'S POSITION.

THE FOLLOWING QUOTE SUCCINCTLY SUMMARIZES THE ACADEMY'S POSITION ON THE ACIDIC DEPOSITION PHENOMENON:

"ACID DEPOSITION, DUE TO THE FURTHER OXIDATION OF SULPHUR AND NITROGEN OXIDES RELEASED TO THE ATMOSPHERE BY ANTHROPOGENIC SOURCES, IS CAUSING WIDESPREAD DAMAGE TO AQUATIC ECOSYSTEMS, INCLUDING LOSS OF BICARBONATE, INCREASED ACIDITY, AND HIGHER CONCENTRATIONS OF TOXIC METALS. AS A RESULT, SEVERAL IMPORTANT SPECIES OF FISH AND INVERTEBRATES HAVE BEEN ELIMINATED OVER SUBSTANTIAL PARTS OF THEIR NATURAL RANGES.

OF THE OPTIONS PRESENTLY AVAILABLE ONLY THE CONTROL OF EMISSIONS OF SULPHUR AND NITROGEN OXIDES CAN SIGNIFICANTLY REDUCE THE RATE OF DETERIORATION OF SENSITIVE FRESHWATER ECOSYSTEMS. IT IS DESIRABLE TO HAVE PRECIPITATION WITH pH VALUES NO LOWER THAN 4.6 to 4.7 THROUGHOUT SUCH AREAS, THE VALUE AT WHICH RATES OF DEGRADATION ARE DETECTABLE BY CURRENT SURVEY METHODS, AS MENTIONED ABOVE. IN THE MOST SERIOUSLY AFFECTED AREAS (AVERAGE PRECIPITATION pH OF 4.1 TO 4.2), THIS WOULD MEAN A REDUCTION OF 50 PERCENT IN DEPOSITED HYDROGEN IONS. CONTROL OF SO<sub>2</sub> FROM NEW ELECTRICAL GENERATING PLANTS ALONE WOULD BE INSUFFICIENT TO ACCOMPLISH THIS, AND THUS RESTRICTIONS ON OLDER PLANTS MUST BE CONSIDERED. FURTHERMORE, THERE ARE NO PROPOSED RESTRICTIONS ON THE EMISSION OF NITROGEN OXIDES, AND THE AMOUNTS OF THESE SUBSTANCES EMITTED ARE EXPECTED TO CONTINUE TO INCREASE.

THE CONTROL OF EMISSIONS OF SULPHUR AND NITROGEN OXIDES FROM FOSSIL FUELS IS NECESSARY TO HALT THE ACIDIFICATION OF SENSITIVE AQUATIC ECOSYSTEMS."

IN SUMMARY, THE ACADEMY CONCLUDED:

- 1) "THAT CONTINUED EMISSIONS OF SULPHUR AND NITROGEN OXIDES AT CURRENT OR ACCELERATED RATES, IN THE FACE OF CLEAR EVIDENCE OF SERIOUS HAZARD TO HUMAN HEALTH AND TO THE BIOSPHERE, WILL BE EXTREMELY RISKY FROM A LONG TERM ECONOMIC STAND POINT AS WELL AS FROM THE STAND POINT OF BIOSPHERE PROTECTION;"
- 2) "THAT BASED ON THE EVIDENCE EXAMINED THE PICTURE IS DISTURBING ENOUGH TO MERIT PROMPT TIGHTENING OF RESTRICTIONS ON ATMOSPHERIC EMISSIONS FROM FOSSIL FUELS AND OTHER LARGE SOURCES."

THE PROVINCE OF ONTARIO IS IN COMPLETE ACCORD WITH THE ACADEMY'S CONCLUSIONS AND RECOMMENDATIONS.

THE PROVINCE OF ONTARIO RECOGNIZES THE ENVIABLE RECORD OF THE STATE OF MICHIGAN IN CONTROLLING EMISSIONS OF OXIDES OF SULPHUR. WE COMMEND THE STATE FOR ITS ACTIONS TO DATE IN THIS REGARD. HOWEVER, THE ULTIMATE ENVIRONMENTAL SIGNIFICANCE OF INDIVIDUAL SOURCES SHOULD NOT BE CONSIDERED IN ISOLATION. WE CANNOT CONSIDER MONROE'S

EMISSIONS ONLY AS THEY AFFECT THE HEALTH AND WELFARE OF THE PEOPLE OF MICHIGAN, JUST AS WE CANNOT CONSIDER INCO'S EMISSIONS ONLY AS THEY AFFECT ONTARIANS. THESE EMISSIONS AND CHANGES AFFECTING EMISSION LEVELS MUST BE VIEWED IN A MUCH BROADER CONTEXT. SPECIFICALLY, ONTARIO SUBMITS THAT EMISSION LEVELS AND ANY CHANGES TO THESE LEVELS MUST BE CONSIDERED IN LIGHT OF THEIR IMPACT ON OTHER JURISDICTIONS.

ONTARIO IS A CONTRIBUTOR TO THE PROBLEM OF ACIDIC DEPOSITION IN OTHER JURISDICTIONS, AS WELL AS IN OUR OWN BACKYARD. RECOGNIZING THIS, IT IS THE POLICY OF THE ONTARIO MINISTRY OF THE ENVIRONMENT, THAT NATIONAL AND STATE AGENCIES AND CITIZENS OF THE U.S. ARE TO BE ACCORDED THE SAME OPPORTUNITIES AS ONTARIO RESIDENTS TO PARTICIPATE IN OUR REGULATORY PROCEEDINGS INVOLVING THEIR INTERESTS ON TRANSBOUNDARY POLLUTION.

ONTARIO RESPECTFULLY SUBMITS THAT THERE IS A NECESSARY AND SUFFICIENT CASE TO ALLOW THE COMMISSION TO ENFORCE THE MICHIGAN "1% OR EQUIVALENT SULPHUR IN FUEL" RULE.

TABLE 7.1

TRENDS AND PROJECTIONS OF SULPHUR DIOXIDE  
EMISSIONS IN ONTARIO (IN METRIC TONS)

YEAR	SO <sub>2</sub> EMISSIONS	NOTES
1970	3,410,000	
1971	3,346,000	
1972	2,870,000	
1973	2,220,000	
1974	2,300,000	
1975	2,230,000	
1976	2,220,000	
1977	2,210,000	
1978	1,557,000	INCO Strike Year
1979	1,240,000	INCO Strike Year
1980	1,713,000	
1981	1,766,000	
1982-83	1,673,000	Assume INCO is at 1950 tons/day, or 646,000 tonnes/yr, and assume Ontario Hydro is at 582,000 tonnes (peak)
1985	1,480,000	Assume Ontario Hydro is at 390,000 tonnes and assume INCO is at 646,000 tonnes
1990	1,350,000	Assume Ontario Hydro is at 260,000 tonnes and assume INCO is at 646,000 tonnes

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